

**GUNNISON COPPER PROJECT
COCHISE COUNTY, ARIZONA
AQUIFER PROTECTION PERMIT APPLICATION
INVENTORY NO. 511633
RESPONSE TO COMMENTS**

VOLUME 1 OF 1

Prepared for:



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APRIL 2017

CRAI Comment

2. *The application must discuss how the effectiveness of the injection/recovery wells are to be measured, the adequacy of the planned monitoring well network, outside of the proposed POC wells and if no additional monitoring is proposed why that is adequate per A.A.C. R18-9-A202(A)(5)(b) and A.A.C. R18-9-A202(A)(6).*

ADEQ Evaluation

The response to RAI 2 is **not** adequate.

Excelsior plans to use the North Star Hydrology (NSH) wells as intermediate monitoring wells for the purposes of early detection. There appear to be gaps in NSH well coverage in the eastern portion of the site. Please provide a discussion on why intermediate wells are not needed in the eastern portion of the site per A.A.C. R18-9-A202(A)(5)(b).

During meetings between Excelsior and ADEQ on January 20, 2017 and Excelsior, ADEQ and the U.S. EPA on January 26, 2017, Excelsior presented geologic and structural cross-sections along with figures that showed the location of a particular well's aquifer test along with the observation wells that were used during the aquifer test. The figure showed the influence of both the faults and bedding planes. The figures also indicated proposed additional intermediate monitoring well locations.

Based upon the response and figures presented during the January 2017 meetings, please include the following:

- Include the mine blocks on the figure or figures to indicate how the NSH wells and other additionally proposed "intermediate wells" would relate to the various mine blocks.
- Indicate whether all NSH wells and other additionally proposed "intermediate wells" would be monitored during which or all phases of mining.
 - if they will not all be continuously monitored, when they will be monitored and provide their screen intervals.
- The figure(s) and cross-section(s) that show each aquifer test well with its associated observation wells, the interpreted responses and which mine blocks were evaluated.
- Figure(s) that provide the combined interpretive responses of all of the conducted aquifer tests along with the proposed locations of additional "intermediate wells".
- Please provide this information, if available, for each stage and if not available, propose compliance schedule items for those "intermediate wells" that would be used in Stage II and later in Stage III.

EXCELSIOR RESPONSE:

The proposed intermediate monitoring well ("IMW") system is designed to act as a real-time early warning system to ensure the appropriate hydraulic control wells are installed and operating during mining. The IMW system includes an inner and an outer ring of monitoring

wells that expand as mining operations expand. IMW's will be monitored for specific conductance and water elevation on a daily basis.

The inner ring is primarily for operational use, allowing operators to observe the immediate effects of changes in operational conditions like injection or recovery rates. Some mining solutions are expected to be observed in these wells due to the sweep of solutions in and out of the margins of the active mining blocks. This is considered normal.

The outer ring is designed as an early warning system to ensure the appropriate hydraulic control wells are installed and operating. Appropriate alert levels (ALs) for specific conductivity will be set in the outer ring of IMW's (discussed later in this response). Increasing trends above alert levels in outer wells would illicit the following response(s):

- Adjust operations to reverse the trend (pull back solutions) and/or
- Install interceptor HC wells (if not already installed)
- Adjust pumping in the appropriate HC wells if needed

The location of the outer IMW's for Stage 1 is based on the aquifer testing that has already been completed in the proposed Stage 1 mining area. This aquifer testing shows the degree of connectivity between the pumping well and the surrounding observation wells. Figures 2-1, 2-2, and 2-3 show the areas of influence of NSH-013, NSH-021C, and NSH-024, which are located within Stage 1 operations. The shaded areas represent the interpreted areas of influence, based on responses in observation wells. The composite area of influence of these three wells, as shown on Figure 2-4, covers all of Stage 1. Figures 2-1, 2-2 and 2-3 provide cross sections through each of the tested wells (NSH-013, NSH-021C, and NSH-024). The intent of the cross sections is to show how the fault network at the site results in hydraulic connections over long distances. Bedding plane fractures, which are shown as dipping to the east, are lesser, but significant flow paths.

The general principle is to locate outer IMW's along the more conductive fluid pathways (bedding parallel and structures), at distances of several hundred feet from the active mining area, in a radial pattern spatially distributed and surrounding the mining area. Irrespective of the IMW's exact location, the aquifer test results show that all the structures are hydrologically well connected, and as long as the IMW intersects either a structure or bedding parallel feature, it should respond to and detect potential migrations outside the active mining area in that direction.

IMW's will consist of existing core, observation or aquifer test wells, supplemented where considered necessary by additional wells to be drilled. Figures 2-5, 2-6, 2-7, and 2-8 show proposed IMW's for Year 1, Year 5, Year 10, and Year 13 respectively. Figure 2-9 shows cross sections through Stage 1 blocks, showing the IMW locations and the significant structures that they intersect. Given the spacing and location of existing holes available to be used as an IMW, two additional holes are proposed to extend coverage beyond existing locations. These holes (shown as stars on the above mentioned figures) will be drilled and installed as IMWs prior to

commencement of production. As new mining blocks come online, any IMWs within that mining block will be abandoned.

A yearly schedule of proposed IMWs for Stages 1 and 2 is provided in Table 2-1, along with well name, location, and open (or screened) interval. The primary structure(s) intercepted by the proposed Stage 1 and Stage 2 IMWs are provided on Table 2-2. IMWs for Stage 3 will be identified according to a compliance schedule in the APP. As operational experience is gained, alternate or additional IMWs may be proposed, but in any event adhering to the general principle of IMWs. Excelsior will notify ADEQ prior to implementing significant departures from this plan.

As mining proceeds and rinsing operations are completed within a block or group of blocks, a selection of the old injection or recovery wells will be converted to IMWs to monitor for later excursions into rinsed areas, as discussed in the revised BADCT demonstration in the response to Comment 16.

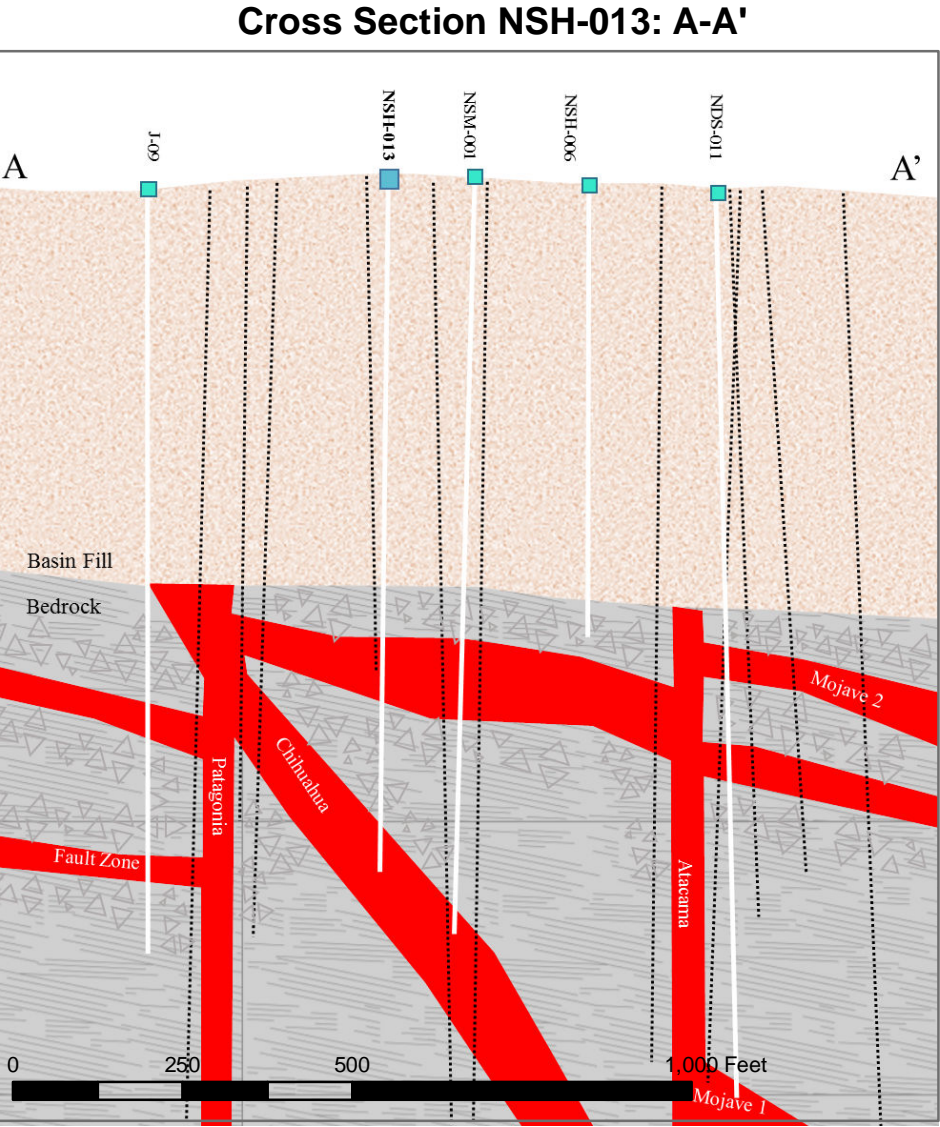
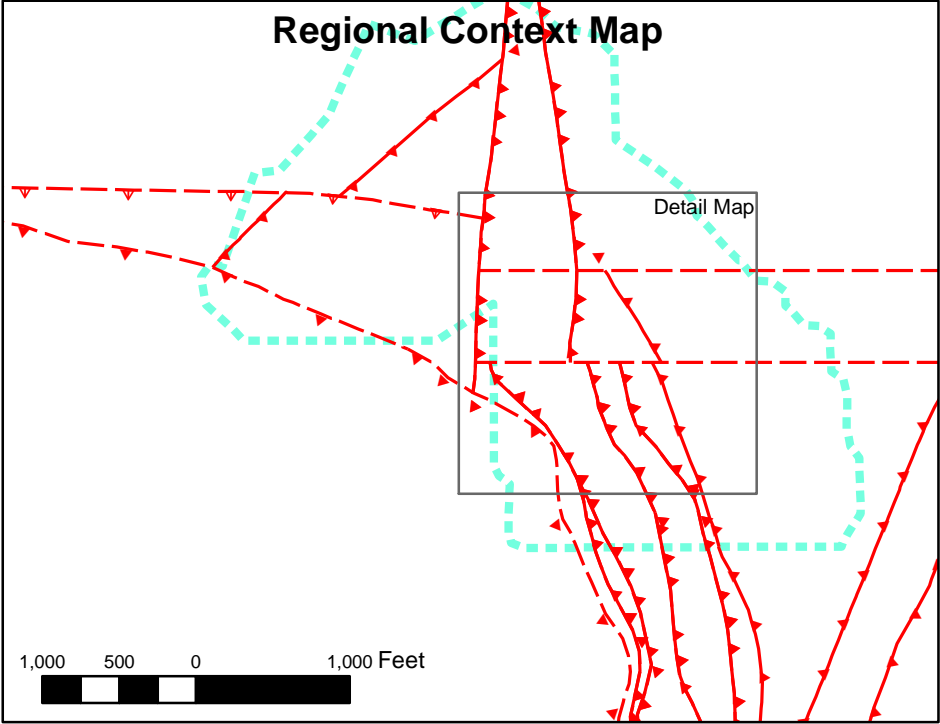
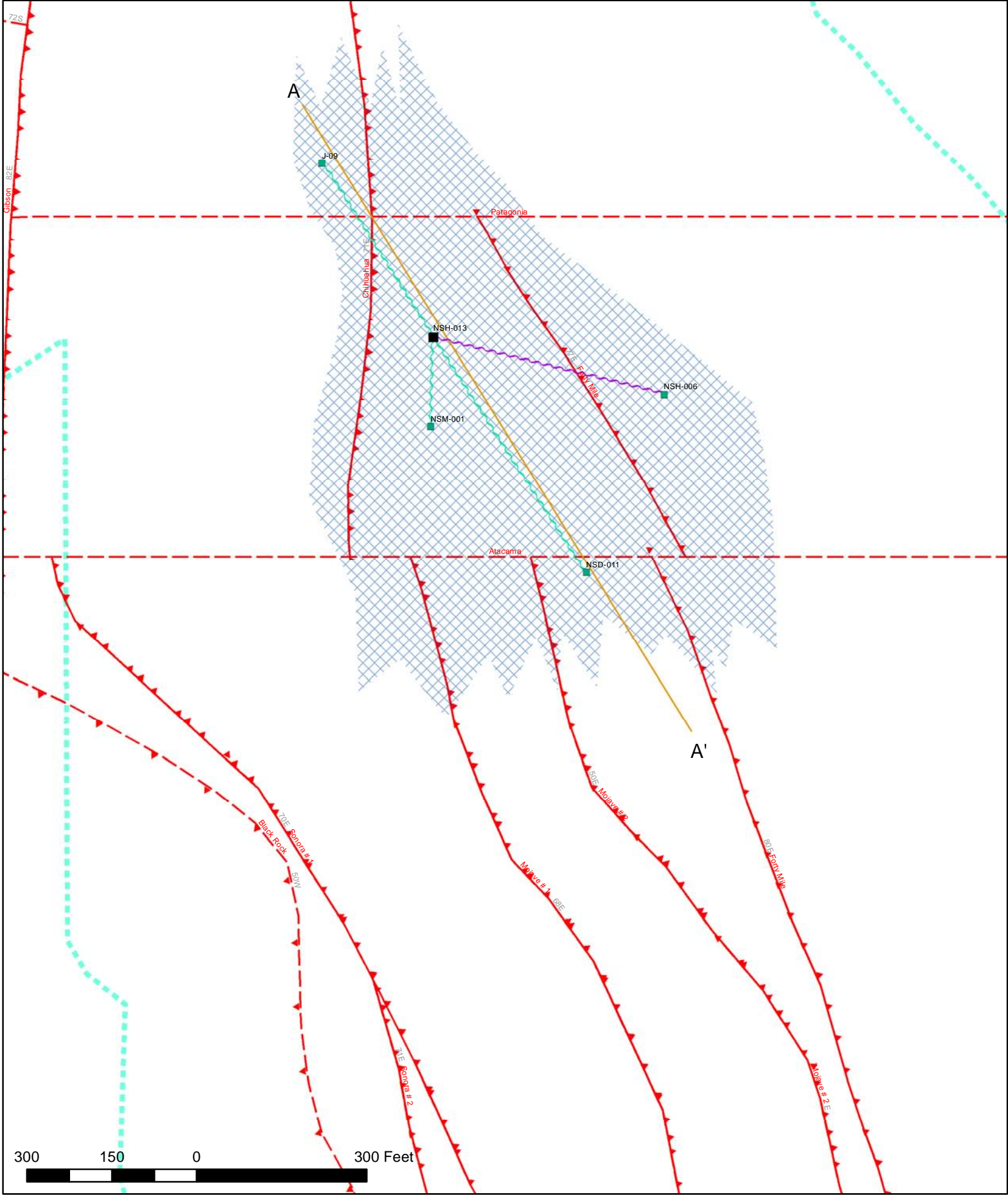
The purpose of the IMWs is to optimize wellfield operations. They are not intended to prevent excursions from the wellfield; that is the purpose of the hydraulic control/observation well network. For this reason, Alert Levels for specific constituents will not be specified. Instead, Alert Levels for specific conductance will be set for the IMWs based on 2 months of daily monitoring.

When an alert level is exceeded in the outer ring of IMWs, Excelsior will notify ADEQ and take one of the following actions:

1. Verify instrument measurements and conduct additional specific conductance measurements for a period of 7 days.
2. If Alert Level exceedances are verified, develop an action plan within one week. The action plan may include any of the following:
 - a. Adjust pumping in the wellfield.
 - b. Adjust operation of HC wells.
 - c. Install additional HC wells, if necessary.

Selected wells that were formerly used for injection or recovery will be used as post-rinse IMWs to identify excursions from rinsed areas. Ambient specific conductivities in these wells, which reflect the post-rinsing groundwater chemistry that meets AWQs and MCLs will be established. Even though the ambient specific conductivity at these wells will be elevated, they will still be appropriate monitoring points for detection of PLS. Alert Levels will be set for post-rinse IMWs using 2 months of specific conductance measurements. If an Alert Level for specific conductance is exceeded, Excelsior will develop a plan of action within 30 days.

Selection of the former injection and recovery wells to serve as IMWs will be based on their connections to major hydraulically-conductive fractures. Excelsior will propose to ADEQ and EPA the wells that will be used as post-rinse IMWs. In general, the wells will adhere to the general principles of locating IMWs as described in more detail above.



Legend

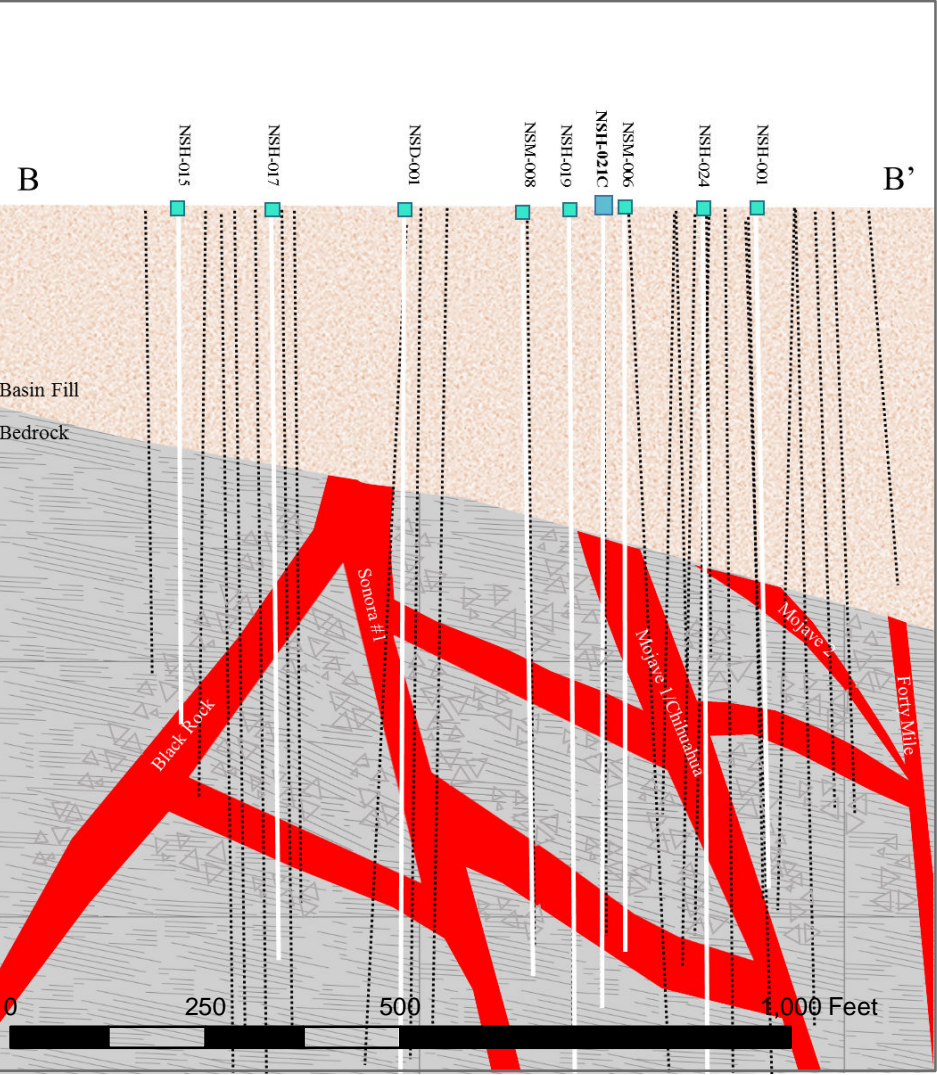
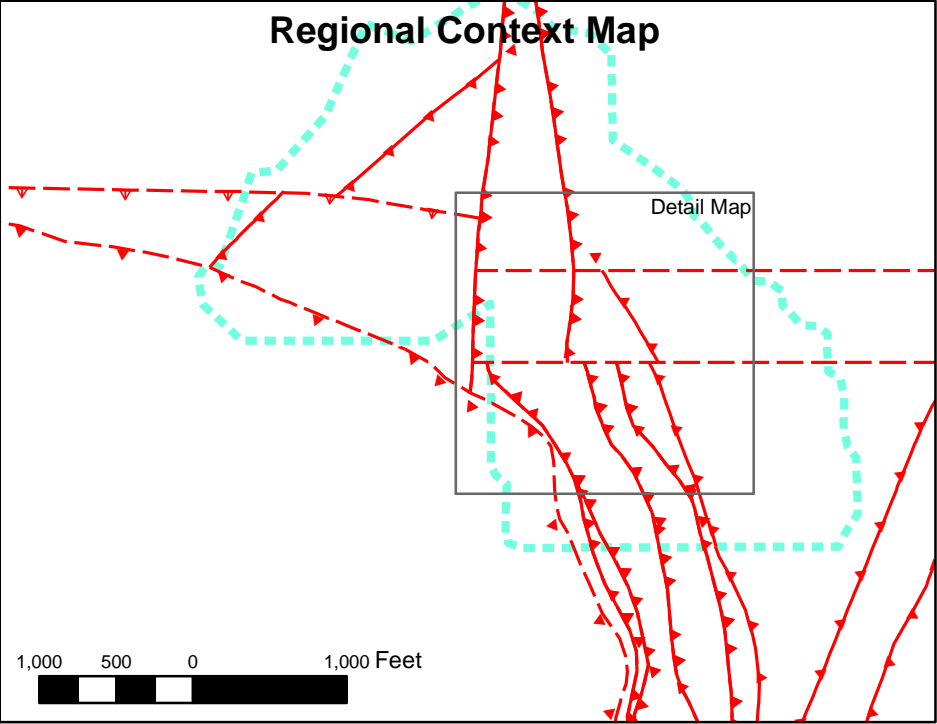
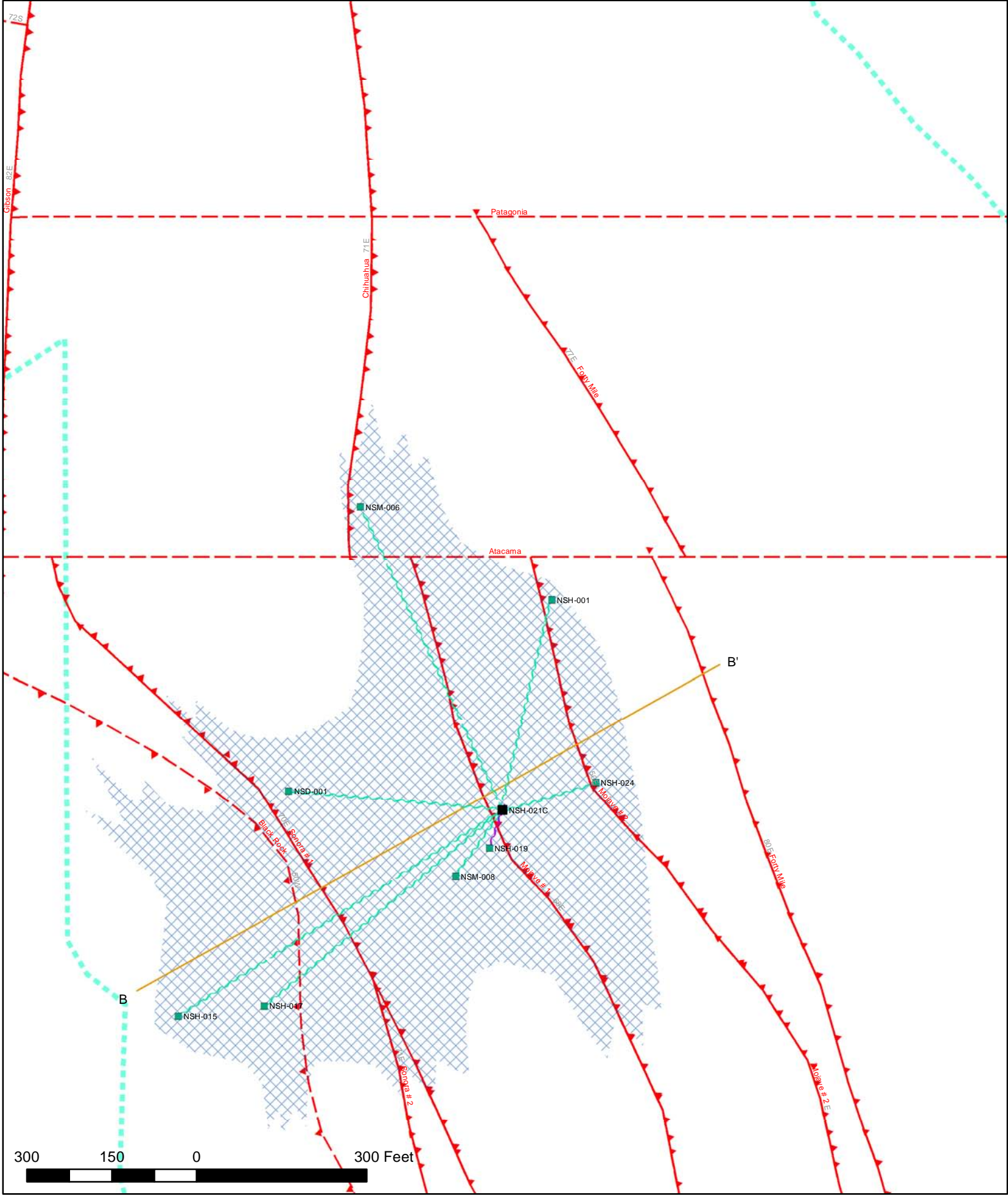
- Observation Well
- Pumping Well
- High Conductivity
- Moderate Conductivity
- Cross Section Line A-A'
- Aquifer Testing Area of Influence
- Approx Fault + Dip Direction (projected at bedrock surface)
- Wellfield Boundary
- Exploration Hole
- Fractured Wallrock

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Date Revised: 2/20/2017

Coordinate System: NAD
1983 StatePlane Arizona
East FIPS 0201 Feet

FIGURE 2-1
AQUIFER TESTING
AREA OF INFLUENCE
NSH-013



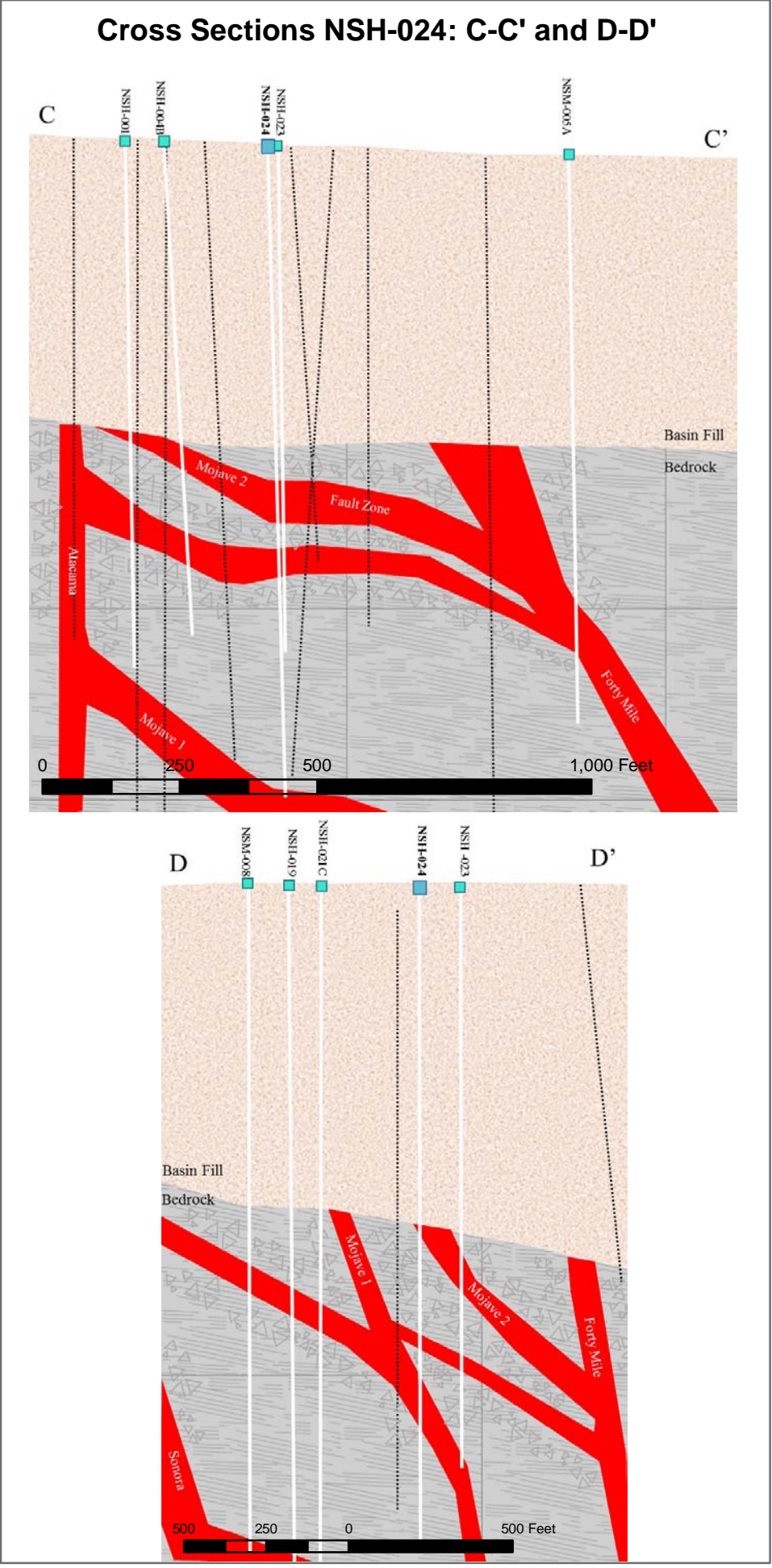
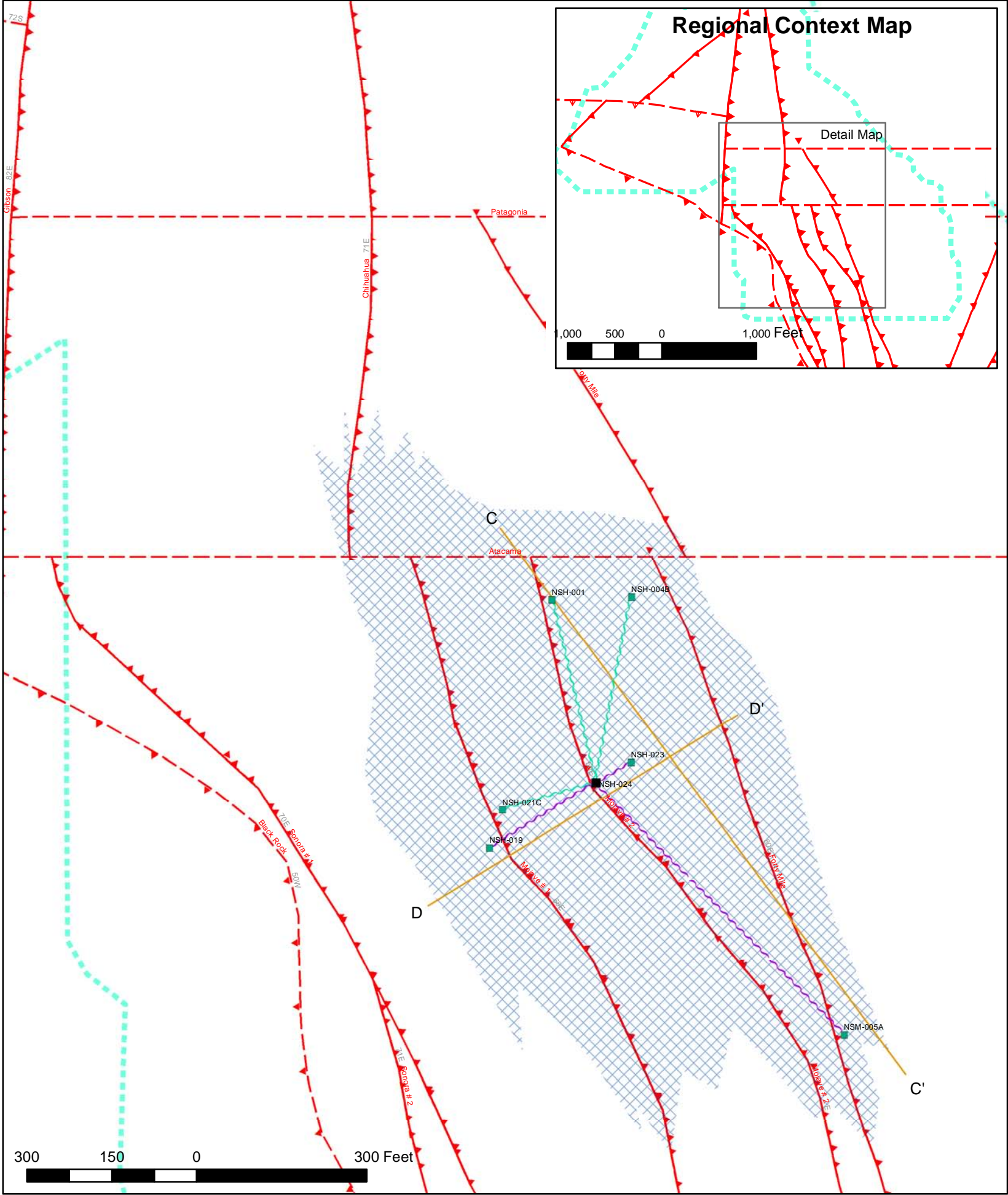
Legend

- Pumping Well
- Observation Well
- High Conductivity
- Moderate Conductivity
- Cross Section Line B-B'
- Aquifer Testing Area of Influence
- Approx Fault + Dip Direction (projected at bedrock surface)
- Wellfield Boundary
- Exploration Hole
- Fractured Wallrock

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FIGURE 2-2
AQUIFER TESTING
AREA OF INFLUENCE
NSH-021C



Legend

- Observation Well
- Pumping Well
- High Flow Strength
- Moderate Flow Strength
- Cross Section Lines C-C' and D-D'
- Section24Labels
- Aquifer Testing Area of Influence
- Approx Fault + Dip Direction (projected at bedrock surface)
- Wellfield Boundary
- Exploration Hole
- Fractured Wallrock

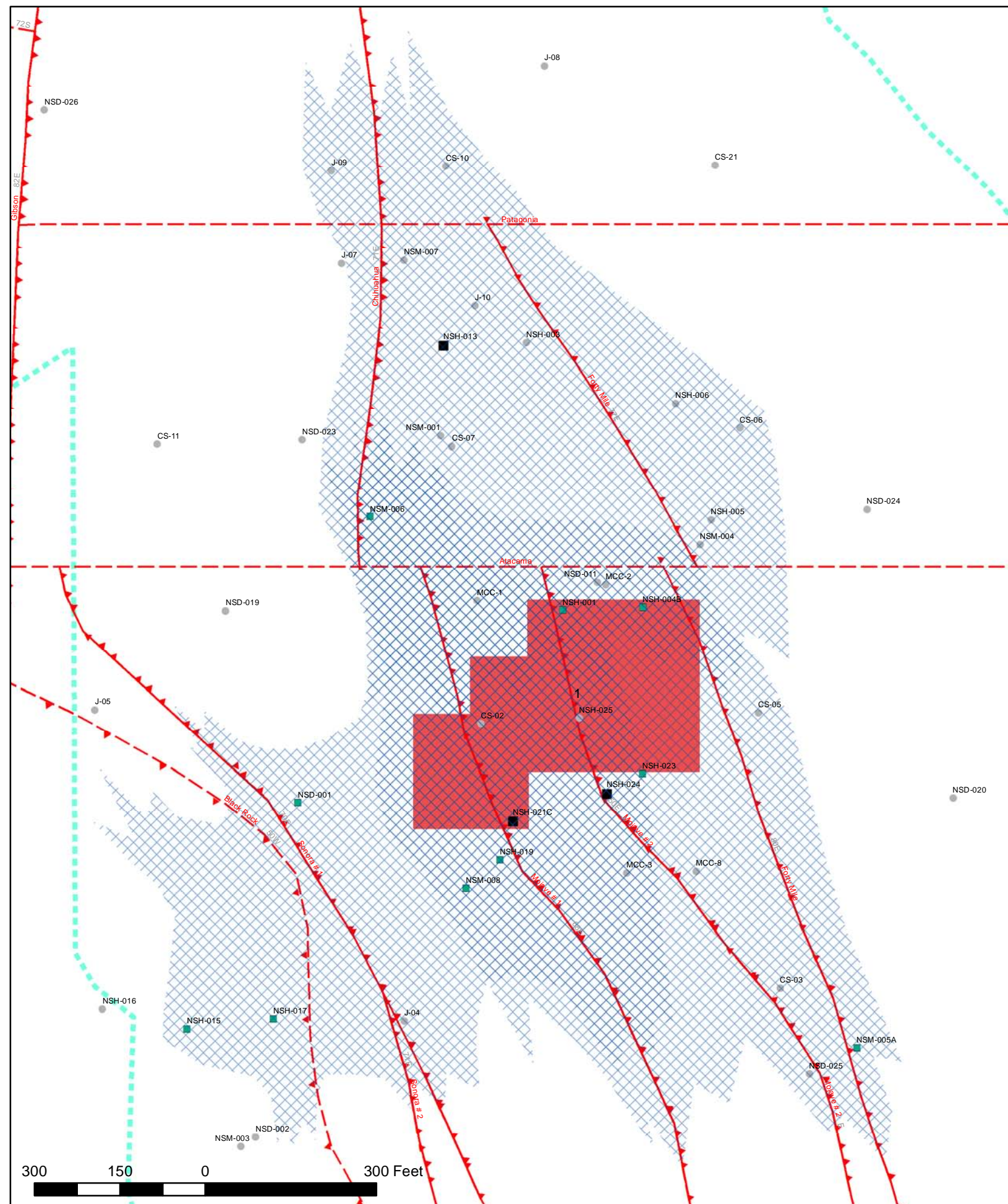
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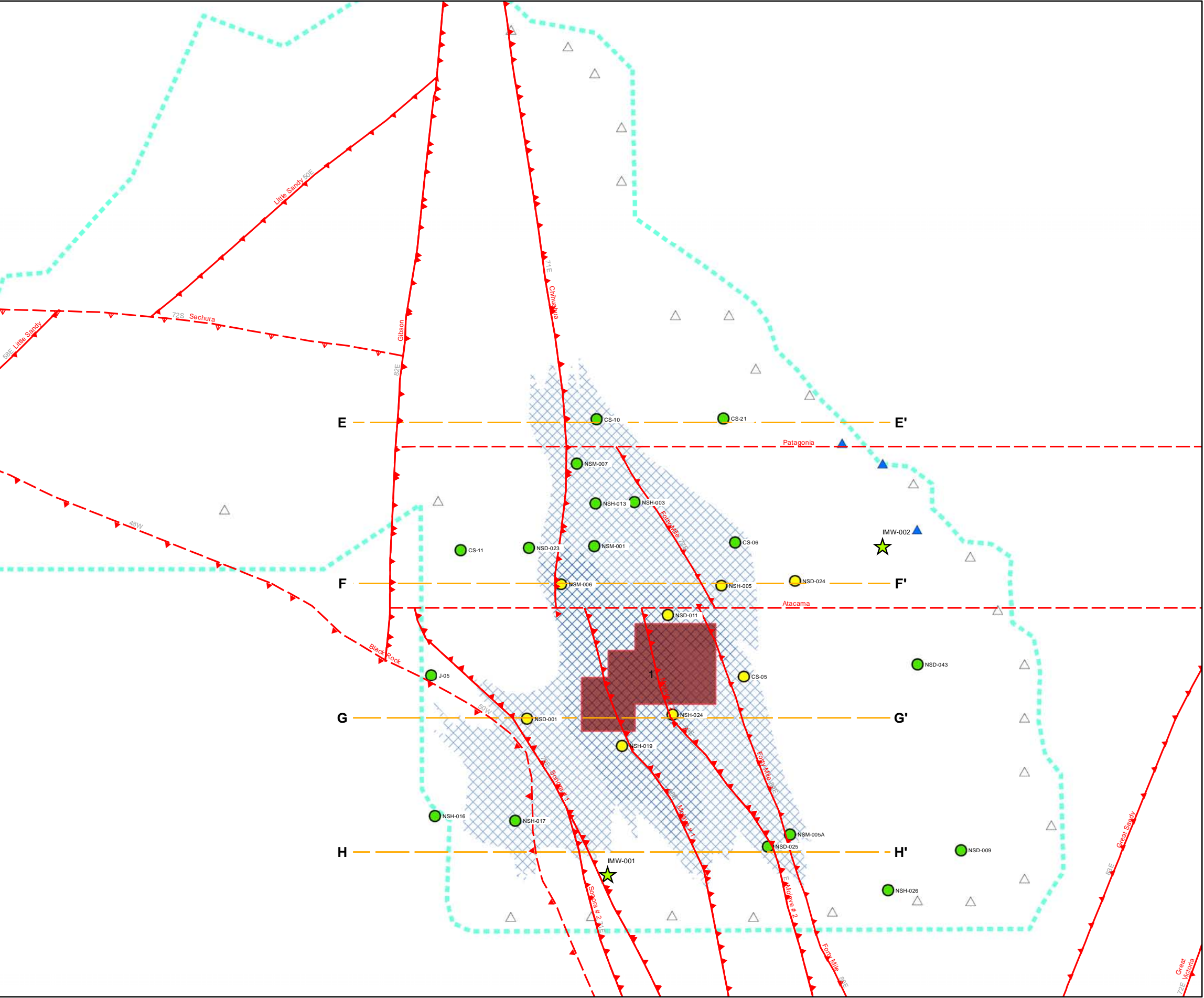
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North Arrow

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FIGURE 2-3
AQUIFER TESTING AREA
OF INFLUENCE
NSH-024





Legend

Approx Fault + Dip Direction (projected at bedrock surface)

Cross Section Lines E - H

New IMW

Outer IMW

Inner IMW

Active HC Wells

Inactive HC Wells

Aquifer Test Influence Area

Wellfield Boundary

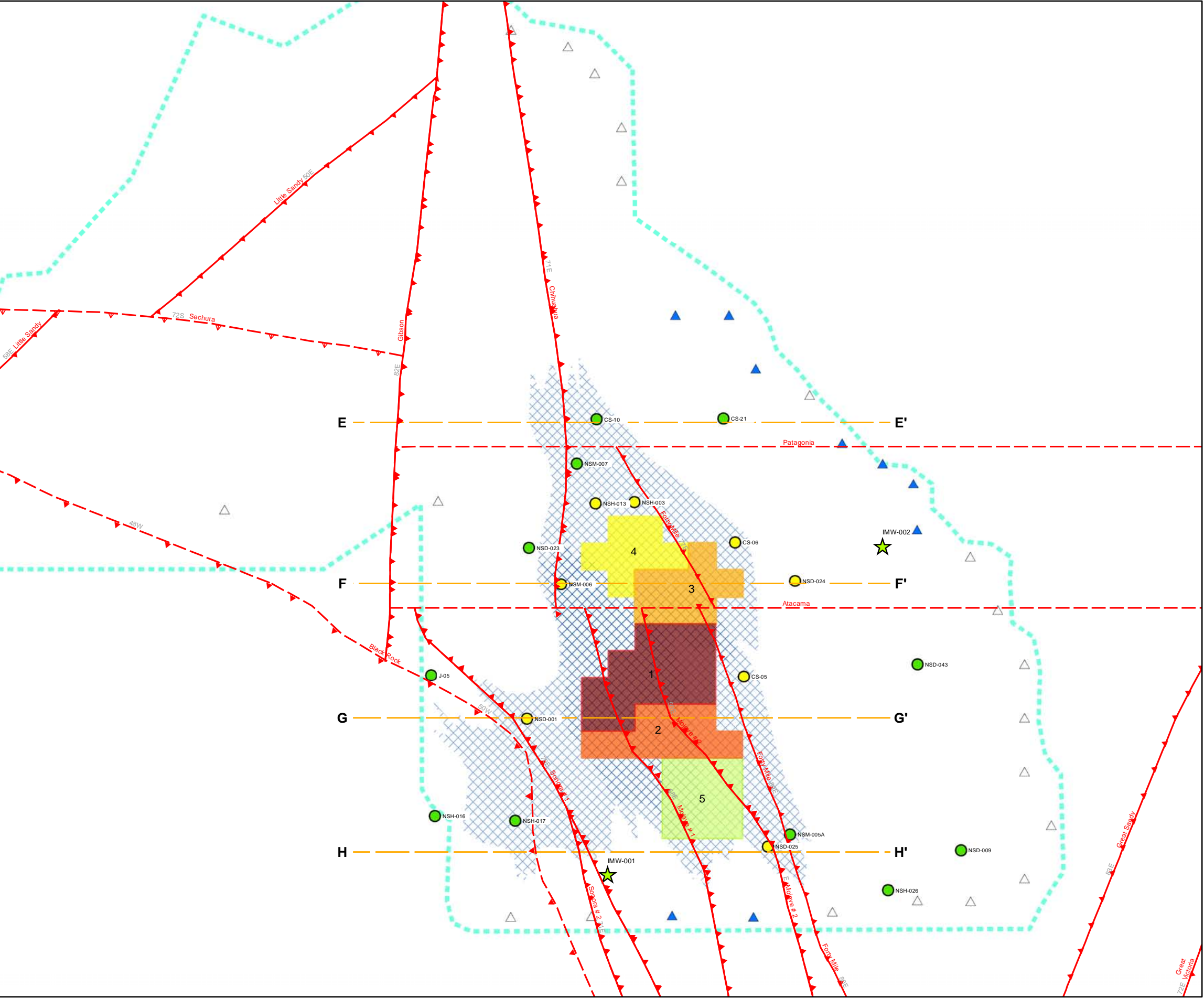
Production
 Year 1

3701850370 Feet

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Coordinate System: NAD 1983
StatePlane Arizona East FIPS 0201
Feet

FIGURE 2-5
INTERMEDIATE MONITORING WELL
LOCATIONS: YEAR 1



Legend

Approx Fault + Dip Direction (projected at bedrock surface)

Cross Section Lines E - H

New IMW

Active HC Wells

Inactive HC Wells

Outer IMW

Inner IMW

Aquifer Test Influence Area

Wellfield Boundary

Production

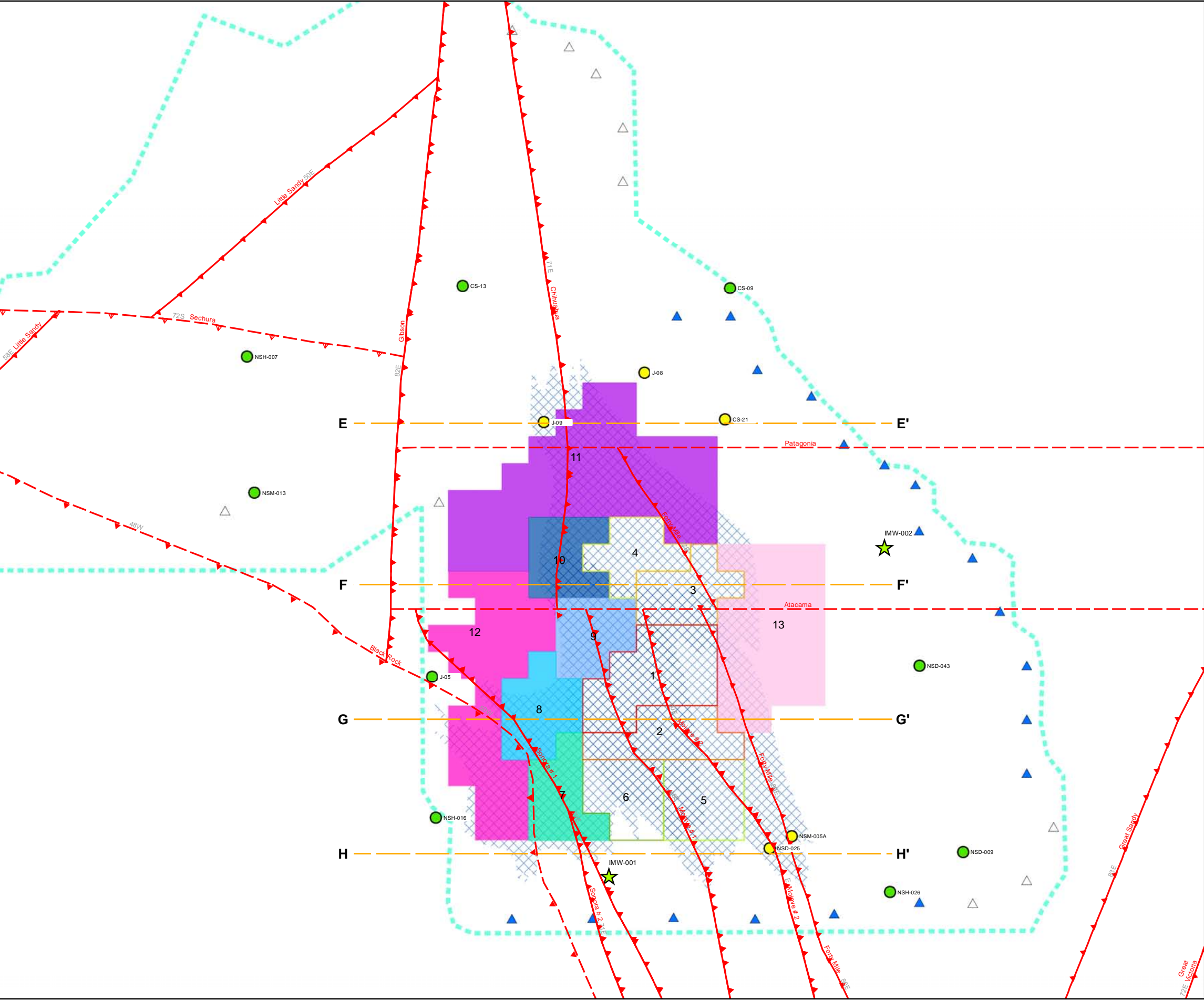
Year 1
Year 2
Year 3
Year 4
Year 5

370 185 0 370 Feet

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Coordinate System: NAD 1983
StatePlane Arizona East FIPS 0201
Feet

FIGURE 2-6 INTERMEDIATE MONITORING WELL LOCATIONS: YEAR 5



Legend

Approx Fault + Dip Direction (projected at bedrock surface)

Cross Section Lines E - H

New IMW

Outer IMW

Inner IMW

Active HC Wells

Inactive HC Wells

Aquifer Test Influence Area

Wellfield Boundary

Production

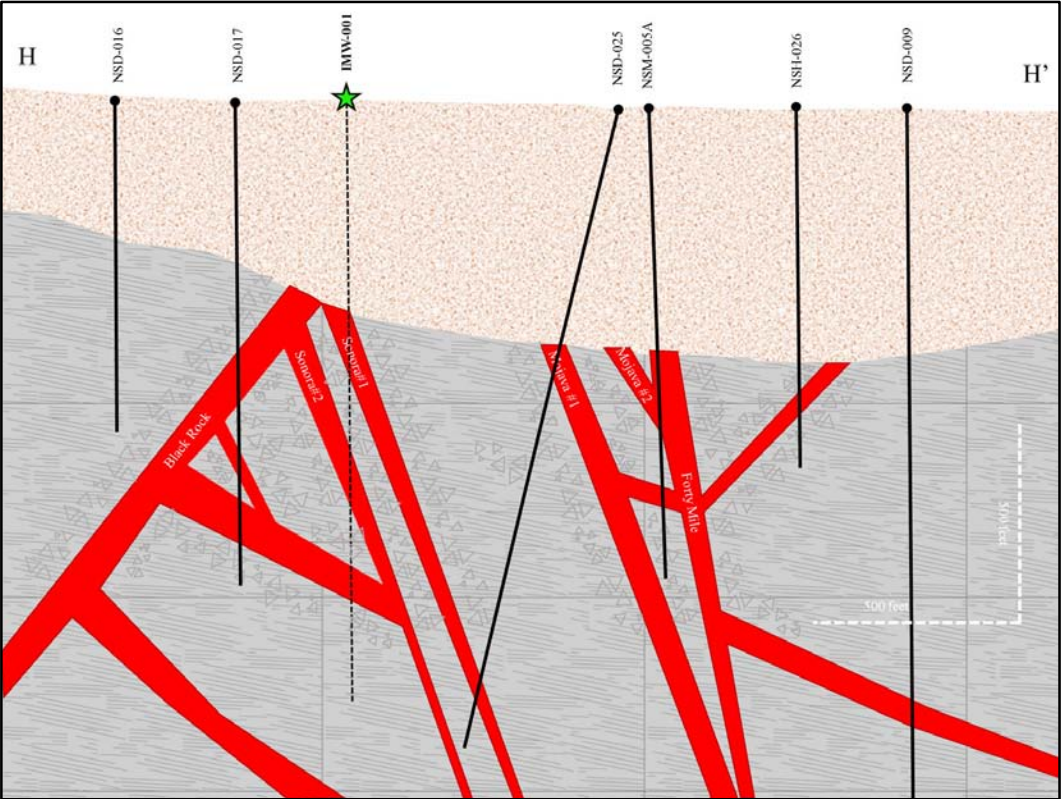
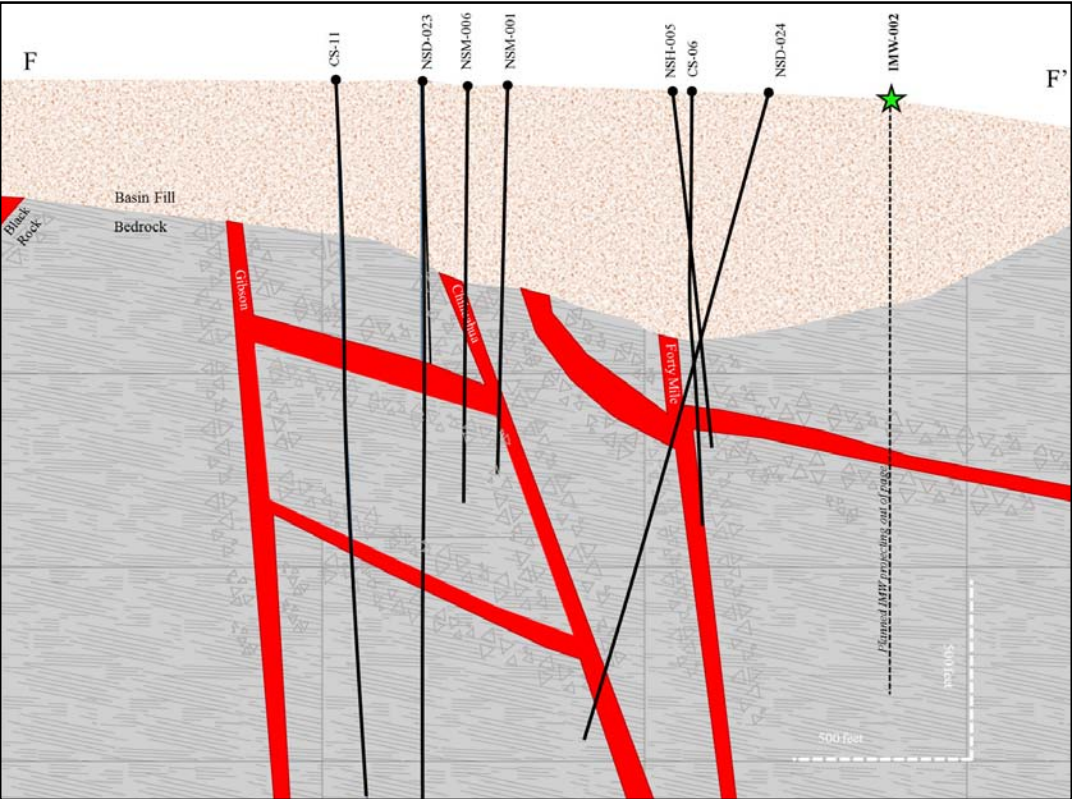
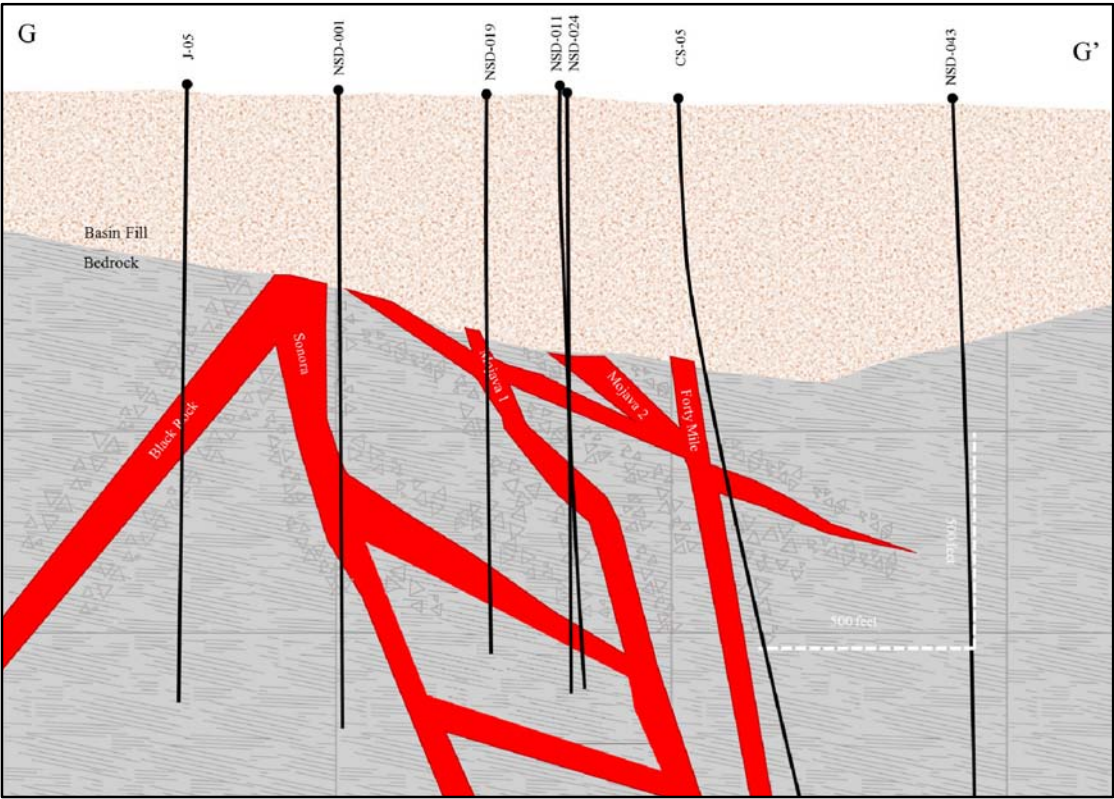
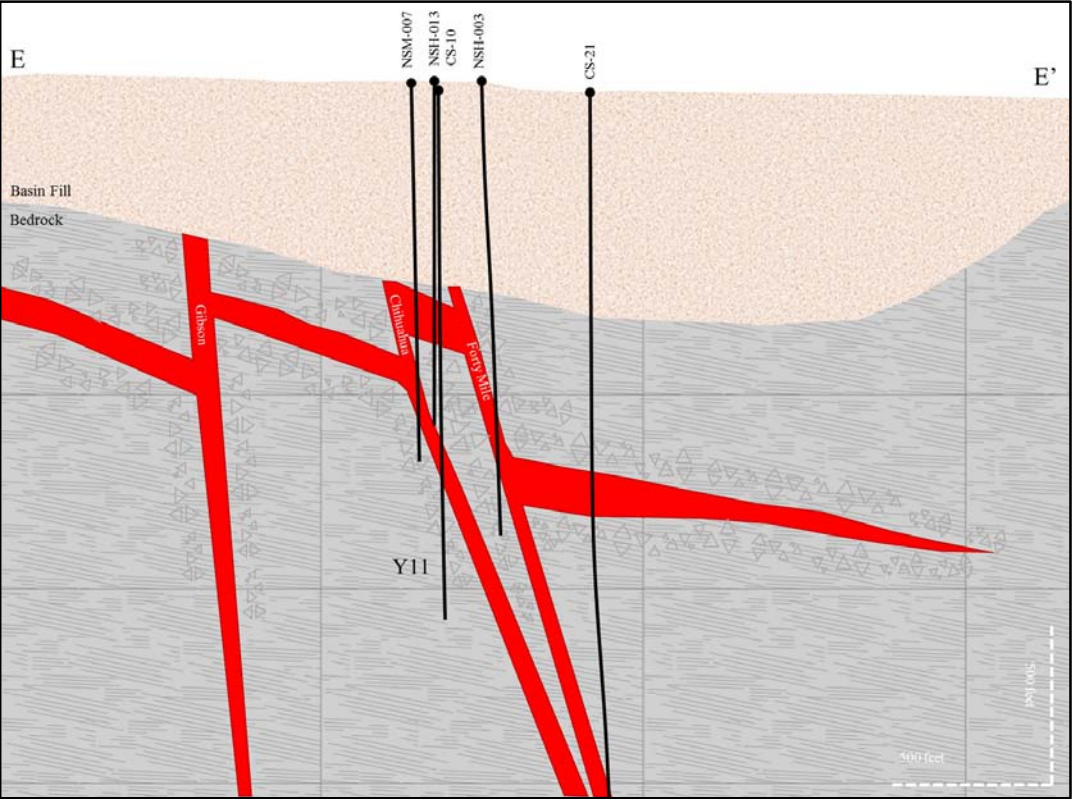
Year 1 (Rinsed)
Year 2 (Rinsed)
Year 3 (Rinsed)
Year 4 (Rinsed)
Year 5 (Rinsed)
Year 6 (Rinsed)
Year 7
Year 8
Year 9
Year 10
Year 11
Year 12
Year 13

370 185 0 370 Feet

Excelsior Mining Arizona Inc.
Gunnison Copper Project
Date: 2/20/2017

Coordinate System: NAD 1983
StatePlane Arizona East FIPS 0201
Feet

FIGURE 2-8 INTERMEDIATE MONITORING WELL LOCATIONS: YEAR 13



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Arizona East FIPS 0201 Feet

Legend

- ★ New IMW
- IMW
- ▨ Pump Test Influence
- ▭ Wellfield Boundary
- Cross Section Lines E - H
- ▲ Active HC Wells
- △ Inactive HC Wells
- Approx Fault + Dip Direction (Faults projected at bedrock surface)
- Production Year 1
- Overburden
- Bedrock
- ▨ Fault Zone
- ▨ Fractured Bedrock
- IMW
- ★ New IMW

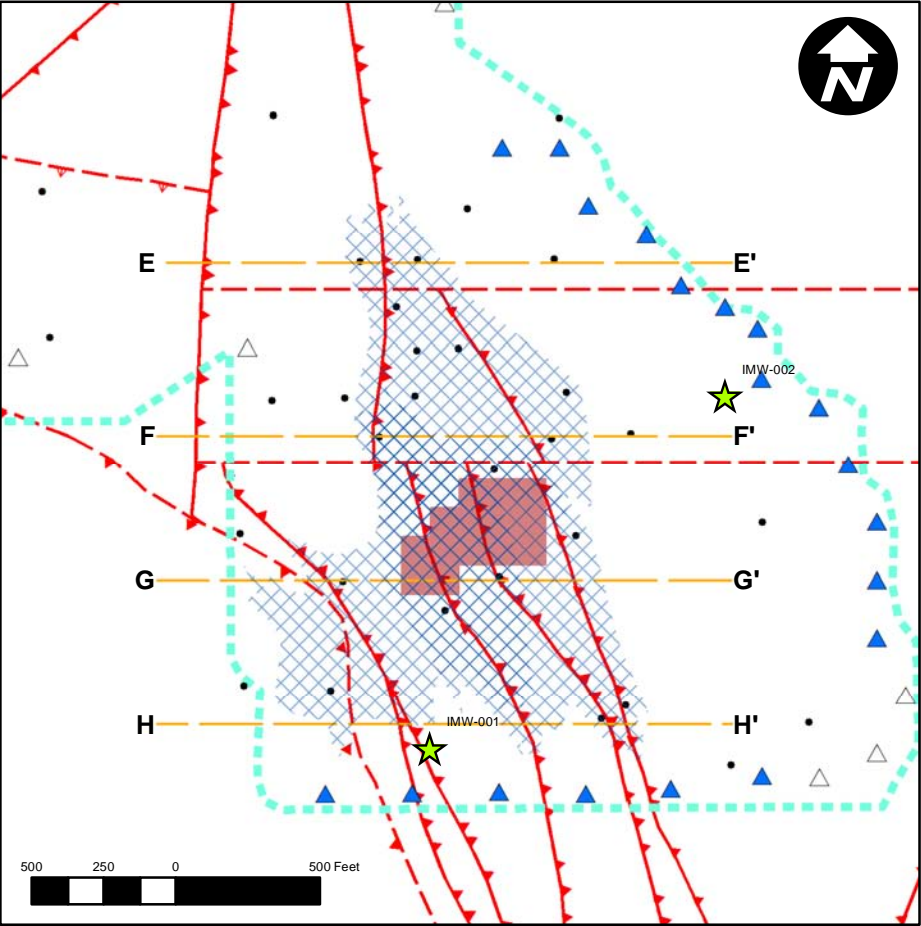


FIGURE 2-9
INTERMEDIATE MONITORING WELL
LOCATIONS - CROSS SECTIONS E-F

Table 2-1

	Intermediate Monitoring Well Activity By Production																								
	Generated 2/8/2017																								
								IMW Activity by Production Year																	
								O Outer IMW				I Inner IMW				A IMW Year Abandoned									
	HOLEID	Azimuth	Dip	Collar Elevation (ft)	Depth (ft)	Lat	Long	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Screened	Screen Depth From (ft)	Screen Depth To (ft)
1	NSH-019	0	-90	4813.772	1410	32.0815879°	-110.0478899°	I	A														Open Hole	638	1410
2	NSH-024	0	-90	4819.07	1445	32.0819062°	-110.0428590°	I	A														Open Hole	625	1445
3	NSD-011	0	-90	4834.35	1438	32.0829234°	-110.0429125°	I	I	A													N	645	1438
4	NSH-005	0	-90	4829.83	1040	32.0832251°	-110.0422664°	I	I	A													Y	747	1019
5	NSM-001	0	-90	4850.525	1150	32.0836335°	-110.0437963°	O	O	I	A												N	575	1150
6	NSD-001	0	-90	4827.17	1506	32.0818639°	-110.0446091°	I	I	I	I	I	I	I	I	A							N	458	1506
7	NSD-023 [#]	180	-70	4857.306	1546	32.0836150°	-110.0445842°	O	O	O	O	O	O	O	O	I	A						N	557	1546
8	NSM-006	0	-90	4847.479	1217	32.0832435°	-110.0441972°	I	I	I	I	I	I	I	I	I	A						N	541	1217
9	CS-10	0	-90	4828.54	1656	32.0849309°	-110.0437687°	O	O	O	O	O	O	O	O	O	O	A					N	730	1656
10	CS-11	0	-90	4863.12	2084	32.0835938°	-110.0454011°	O	O	O		O	O	O	O	O	I	A					N	481	2084
11	NSH-003	0	-90	4846.072	1432	32.0840811°	-110.0478867°	O	O	O	I	I	I	I	I	I	I	A					Y	1232	1399
12	NSH-013	0	-90	4850.415	1070	32.0840678°	-110.0437796°	O	O	I	I	I	I	I	I	I	I	A					Open Hole	650	1070
13	NSM-007	0	-90	4844.188	1168	32.0844803°	-110.0440050°	O	O	O	O	O	O	O	O	O	O	A					N	600	1168
14	NSH-017	0	-90	4806.813	1181	32.0808222°	-110.0447493°	O	O	O	O	O	O	I	I	I	I	I	A				Y	940	1181
15	CS-05	0	-90	4817.75	2034	32.0822957°	-110.0419996°	I	I	I	I	I	I	I	I	I	I	I	A				N	645	2034
16	CS-06	0	-90	4831.4	2160	32.0836703°	-110.0421043°	O	O	I	I	I	I	I	I	I	I	I	I	A			N	718	2160
17	NSD-024 [#]	270	-70	4823.291	1972	32.0832737°	-110.0413848°	I	I	I	I	I	I	I	I	I	I	I	I	A			N	750	1972
17.5	IMW-001*	270	-70	4798	1600*	32.0802743°	-110.0436410°	O	O	O	O	O	O	O	O	O	O	O	O	O	A		N (?)	600 (approx)	1600 (approx)
18	NSD-009	0	-90	4788.19	1793	32.0805145°	-110.0393900°	O	O	O	O	O	O	O	O	O	O	O	O	O	A		N	620	1793
19	NSD-025 [#]	270	-70	4789.8	1644	32.0805525°	-110.0417146°	O	O	O	O	I	I	I	I	I	I	I	I	I	A		N	637	1644
20	NSH-026	0	-90	4794.091	905	32.0819062°	-110.0428590°	O	O	O	O	O	O	O	O	O	O	O	O	O	A		Open Hole	625	905
21	NSM-005A	0	-90	4786.902	1172	32.0806787°	-110.0414465°	O	O	O	O	O	O	I	I	I	I	I	I	I	A		N	592	1172
22	CS-21	0	-90	4809.94	2171	32.0849350°	-110.0422414°	O	O	O	O	O	O	O	O	O	O	I	I	I	I	A	N	688	2171
23	NSD-043	0	-90	4802.365	1736	32.0824201°	-110.0399104°	O	O	O	O	O	O	O	O	O	O	O	O	O	O	A	N	630	1736
23.5	IMW-002* [#]	180	-70	4800	1600*	32.0836339°	-110.0403275°	O	O	O	O	O	O	O	O	O	O	O	O	O	O	A	N (?)	750 (approx)	1600 (approx)
24	J-05	0	-90	4836.75	1475	32.0823131°	-110.0457580°	O	O	O	O	O	O	O	O	O	O	O	O	O	O		N	415	1475
25	NSH-016	0	-90	4812.227	820	32.0808698°	-110.0457147°	O	A	O	O	O	O	O	O	O	O	O	O	O	O		Y	301	701
26	CS-09	0	-90	4832.68	2337	32.0862792°	-110.0421815°												O	O	O	O	N	685	2337
27	CS-13	0	-90	4767.88	1251	32.0863042°	-110.0453846°												O	O	O	O	N	462	1251
28	NSH-007	0	-90	4773.177	620	32.0855837°	-110.0479752°												O	O	O	O	Y	536	616
29	NSM-013	0	-90	4881.136	953	32.0841926°	-110.0478866°												O	O	O	O	N	405	953
30	J-08	0	-90	4810.4	1350	32.0854170°	-110.0432095°													I	I	I	N	661	1350
31	J-09	0	-90	4824.4	1158	32.0849096°	-110.0444145°													I	I	I	N	591	1158
34	* indicates planned IMW																								
	[#] indicates ongled IMW																								

Table 2-2

	Structure	NSH-017	NSD-001	NSD-025	IMW-001	NSH-016	NSH-024	NSD-011	NSM-005A	CS-05	CS-06	NSH-005	NSH-026	IMW-002	NSD-023	NSD-024	NSM-001	NSM-006	NSH-013	CS-10	NSM-007	CS-21	J-08	NSM-013	NSH-007	CS-11	CS-13	NSH-019	J-05	NSD-009	NSH-003	NSD-013	CS-09	J-09	
1	Black Rock	1	2	2	2	1																													
2	Bedding Parallel 840	2	2	2	2	2																													
3	Bedding Parallel 842	1	2	2	2	2																													
4	Bedding Parallel 843	2	2	2	2	2																													
5	Bedding Parallel 844	2	1	2	2	2																													
6	Sonora #1 & 2		1	1	1		2								2														2						
7	Bedding Parallel 823		2				1								1		2	2	2	2	2						1	1	1						
8	Bedding Parallel 845		2	2	2		2																												
9	Bedding Parallel 846		2	2	2		2																												
10	Bedding Parallel 848		2	2	2		2																												
11	Bedding Parallel 852		2	2	2		2																							1					
12	Mojave #1			1			1	2	2																				2						
13	Bedding Parallel 858			2			1	1	2						2		2																		
14	Bedding Parallel 856			2			2	2	1						2		2																		
15	Mojave #2						1	1	2						2		2																		
16	Forty Mile						2	2	1	2	2	2	2	2	1		1	2													2				
17	Bedding Parallel 828								2	2	2	2	2	2	2	2	2	2													1				
18	Bedding Parallel 826								2	2	2	2	1		2	2	2																		
19	BP 827								2	1	1	1			2	2	2																		
20	Atacama														1	1	2	2	2																
21	Chihuahua														2		1	1	1																
22	Bedding Parallel 837																2	2	2																
23	Gibson														2		2	2	2							2	2	2							
24	Bedding Parallel 823		2				1								1		2	2	2	2	2						1	1	1						
25	Bedding Parallel 860																2	2	2	2	2														
26	Chihuahua																1	1	1	1	1	2	2												
27	Bedding Parallel 825																2	2	2	2	2	1	1												
28	Bedding Parallel 824																1	2	1	1	1		1												
29	Patagonia																			2	2	2	2	2	2										
30	Bedding Parallel 822																									1	2								
31	Sechura													1												2	1								
32	Little Sandy													2												2	2								

CRAI Comment

3. Section 5.4, Groundwater Quality

In the course of monitoring, Excelsior detected petroleum odors in these and other coreholes, and free product in CS-10 and CS-14. Samples were collected as part of a study of Light Non-Aqueous Phase Liquids (LNAPLs) in groundwater by Haley & Aldrich (2015).

- a. Please provide additional information regarding the lateral and vertical extent of the petroleum plume in the groundwater per A.A.C. R18-9-A202(A)(8)(b)(vi and vii).*

ADEQ Evaluation

The response to RAI 3a is **not** adequate.

Excelsior indicates that “The extent of petroleum in CS-10 and CS-14 appears to be limited to the immediate area of the boreholes and also indicated that when CS-10 and CS 14 were drilled (1971) it was common to add diesel or any other inexpensive hydrocarbon compounds to the drilling mud to lubricate drill rods. The wells nearest to these borings (NSH-13 and NSH-9, respectively) do not contain LNAPL.” In addition, dissolved petroleum compounds have been detected in NSH-15, NS-16 and NSH-17 immediately downgradient of the closed “The Thing” underground storage tank release. The detected petroleum compounds are less than their respective aquifer water quality standards (AWQS).

Excelsior must provide a brief description on whether NSH-13 and NSH-9 are constructed in a similar manner as CS-10 and CS-14.

EXCELSIOR RESPONSE:

Information regarding CS-10 and CS-14 are provided in the table below:

	Date Completed	Borehole Depth (feet)	Casing Diameter (inches)	Cased to (feet)	February 2017 Depth to Water (feet)
CS-10	9/27/1971	1656	3.5	720	617.7
CS-14	10/14/1971	1375	4.0	465	426.6

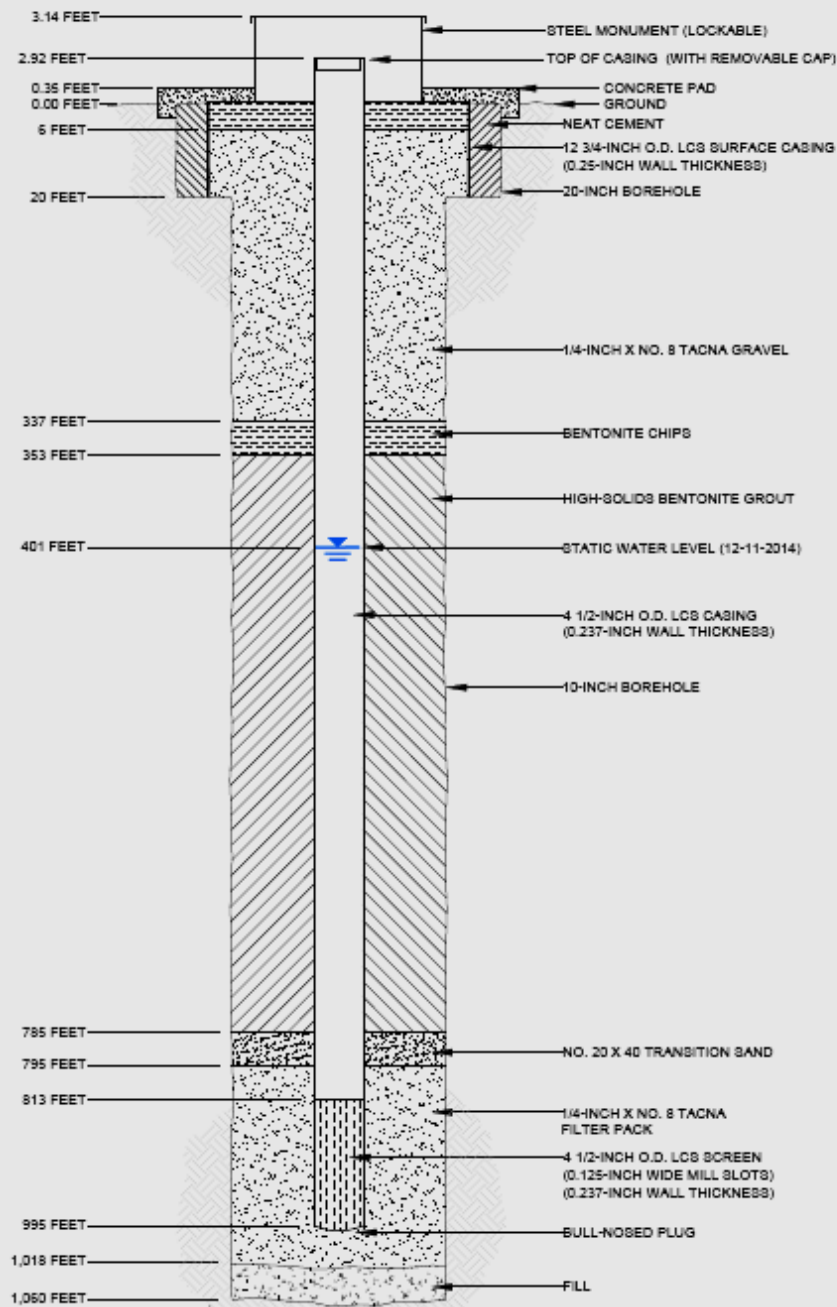
Both are open coreholes in bedrock below the casing. The water levels measured in February 2017 are within the cased intervals.

Construction information regarding NSH-9 and NSH-13 are provided in the table below:

	Date Completed	Borehole Depth (feet)	Casing Diameter (inches)	Screened Interval (feet)	October 2016 Depth to Water (feet)
NSH-9	November 2015	1060	4.5	813-995	370
NSH-13	December 2015	1070	8.625	646-1070 (open borehole)	658

Construction of NSH-9 and NSH-13 was documented in Appendix F of the APP Application. The as-built diagrams from Appendix F are provided below.

Except for NSH-13, these wells are unsuitable for monitoring for LNAPL, as their screen/open intervals are submerged. Presence of LNAPL in CS-10 and CS-14 is consistent with addition of petroleum to lubricate drill rods, as stated in our original response.



**HALEY
ALDRICH**

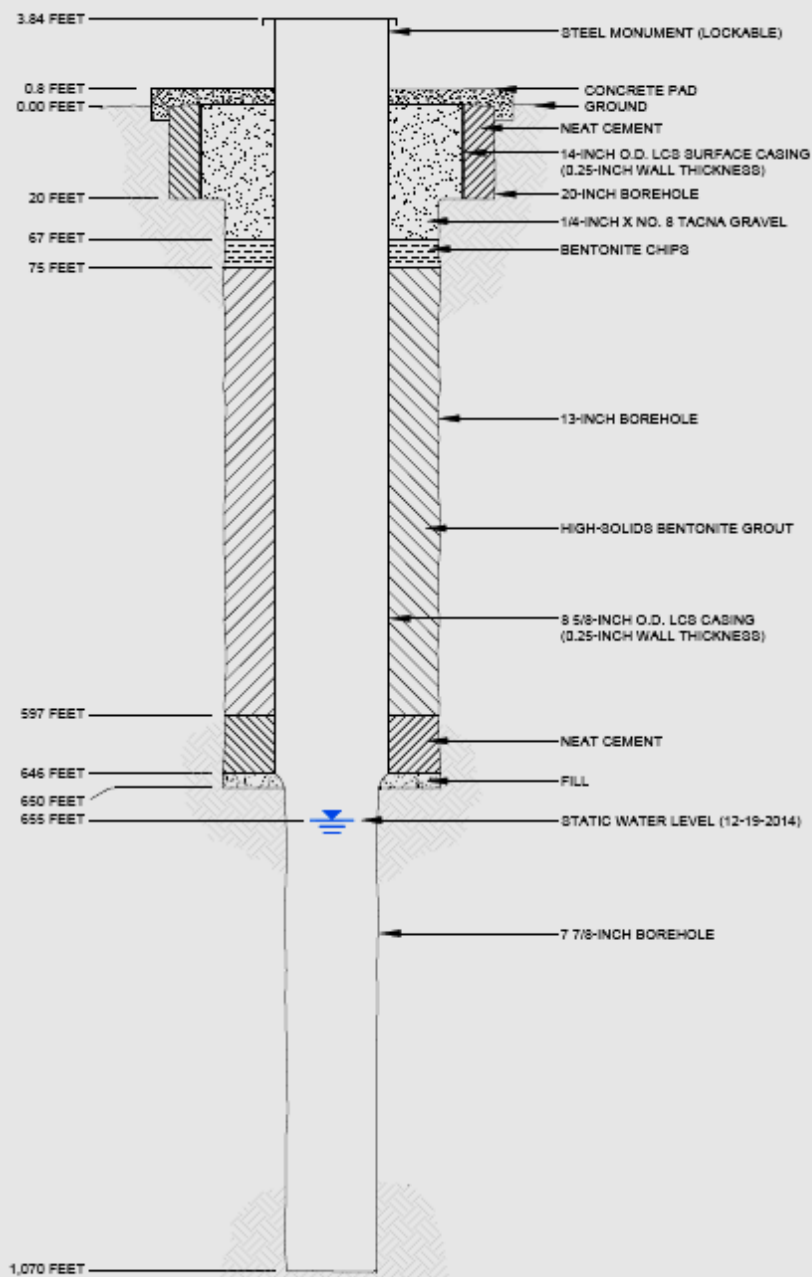
EXCELSIOR MINING CORPORATION
GUNNISON, ARIZONA

NSH-009 AS-BUILT DIAGRAM

SCALE: NONE
JULY 2015

FIGURE 5

ANDERSEN, DAVE Printed: 7/17/2015 1:45 PM Layout: NSH-013 - AS-BUILT
 C:\PROJECTS\EXCEL MINING CORP\3881-MINE PLANNING\CAD\3881-002.DWG



**HALEY
ALDRICH**

EXCELSIOR MINING CORPORATION
 GUNNISON, ARIZONA

NSH-013 AS-BUILT DIAGRAM

SCALE: NONE
 JULY 2015

FIGURE 8

CRAI Comment

8. Section 5.8 (Groundwater Flow Model)

Groundwater flow and particle-track modeling (Appendix I) has shown that migration of mining solutions outside the wellfield can be prevented using this approach.

Per A.A.C. R18-9-A202(A)(5)(b):

- a. Please clarify how the groundwater flow and particle-track modeling has accounted for all the injection and recovery wells in all 3 phases of the project without having accurate design and layout of these injection and recovery wells.

ADEQ Evaluation

The response to RAI 8a is **not** adequate.

Excelsior explains that each model grid represents a 5-spot injection/recovery well pattern since the model grid in the ore body is 75 x 75 feet in size and is 300 x 300 feet in size outside the ore body. ADEQ understands the limitations on how the groundwater flow model works.

ADEQ has the following additional requests to help clarify the sequence of mining and to help clarify closure costs for each phase of mining.

- i. Figure 8-1 Updated Mining Block Sequence provides a color scheme for each mine block over 17 years. Some of the colors are very close to each other and are difficult to differentiate. ADEQ requests that the colors be better differentiated between the mine blocks so the sequence is clearer by having different types of hatching and/or other distinguishing mark added to the colors to help clarify mining sequence.
- ii. Figure 8-2 Particle Starting Location for Mining Year 5 includes years 2 through 5 but does not include year 1. Please provide a rationale as to why year 1 was not included in the particle tracking. In addition, ADEQ requests that particles for year 1 be allowed to run with only year 1 pumping, then particles for year 5 be allowed to run with only year 5 pumping and year 5 hydraulic control wells. ADEQ also requests additional, similar type model runs for year 10 (mining years 6 to 10), particles added for those mine blocks added during those years and all hydraulic control wells that will be installed and operating at year 10 so closure costs may be determined if there was a cessation of mining during or after Stage I is complete. ADEQ requests similar individual evaluations, if appropriate for Stage II and/or Stage III, or otherwise propose compliance schedule items for similar type modeling for Stage II and Stage III or Stage III.

EXCELSIOR RESPONSE:

Figure 8-1 has been revised as requested to more clearly differentiate the mining blocks by year of operations.

Figure 8-2 in our previous submittal illustrates an example which shows how particles were placed around active mining blocks for Year 5 mining only. For the model simulations, particles were placed around each active mining block at the start of each mining year. So for Year 1, particles were placed around Block 1, at the start of the mining period. For Year 2, particles were placed around Blocks 1 and 2. For Year 3, particles were placed around Blocks 1, 2 and 3, and so on for the other years. For the simulation of Year 5, particles were placed at the start of each of Years 1-5, (666 total), around each years active mining area. These particles then moved with the groundwater until captured by hydraulic control or drawn into the wellfield during shutdown simulations. By Year 5, mining block 1 is inactive and in rinse, therefore the original Figure 8-2 shows no particles around the Year 1 mining block; particles were, however, released around mining block 1 when the Year 1 mining block was active.

Year 1 Simulation

In order to better clarify how mining blocks can be closed in the event of a premature cessation of operations, Excelsior has made additional model simulations to evaluate capture of potential solution excursions from mining operations at Years 1 and 5. Figure 8-2 depicts a closure scenario after Year 1 of mining. Particles are released at the beginning of mining and at the end of the first year. Because it has been assumed that there is equal injection and recovery in mining blocks, no net pumping in the mining block is simulated. No control strategies are simulated, such as local over-pumping to control detected excursions. Particles released around the outside of the mining block migrate away from the mining block. This is a conservative assumption because normal mine operations will create a sweep affect around the perimeter of a mining block specifically to recover mining solutions. For this scenario it was assumed that after one year of mining, recovery wells around the perimeter would be operated to pull back any potential solutions as represented by particles in the model. The pumping rates assumed are shown on Figure 8-2 and indicate that high pumping rates on the order of 20 gpm per well would be used along the southern boundary of the mining block. Along other boundaries, a pumping rate of 10 or 3 gpm per well was used. As illustrated in Figure 8-3, all particles are recovered three years after cessation of mining; most are recovered within one year. At least initially, the total amount of recover pumping would be about 153 gpm.

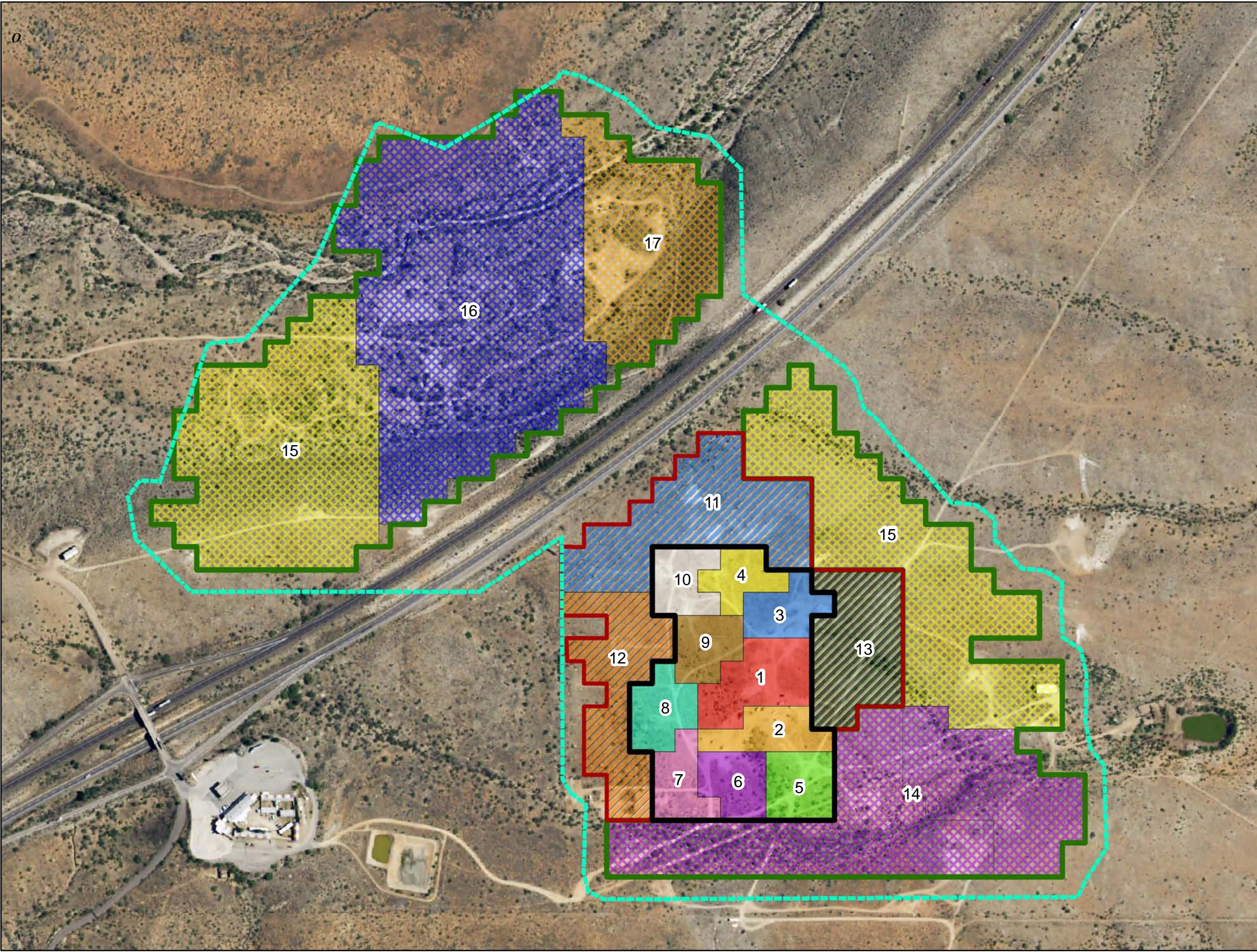
Year 5 Simulation

A similar analysis was done for the scenario where mining ceases after mining Year 5. Figure 8-4 depicts the boundaries of mining blocks 1 through 5 as well as the locations of permitted wells in the mining blocks and operational hydraulic control wells. All of these wells are assumed to be available for recovery operations. Figure 8-5 shows the drawdown created by pumping selected boundary and hydraulic control wells 3 years after the start of recovery operations (end of Year 8) as well as the assumed pumping rates for recovery and HC wells. The maximum drawdown predicted by the model (Layer 3) is 86 feet at the southern boundary of the Year 5 mining block.

The paths of particles (in layers 3, 4, and 5) sequentially released around mining blocks is shown in Figure 8-6. Particles initially migrate away from mining blocks, but then the paths are reversed and particles are captured when recovery operations begin after mining year 5. All particles are captured within 3 years after recovery operations start with most being captured within one year of recovery pumping. The only HC wells needed to be operated in this scenario are the two HC wells along the southern boundary of the wellfield.

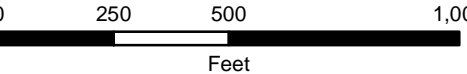
Excelsior does not believe modeling closure scenarios after year 5 is necessary given that Excelsior will be reviewing the model performance as compared to actual operations as part of the planned review of closure cost bonding after year 6. Modeling at that time will incorporate updates based on operations and monitoring data.

Excelsior has proposed that one well every 1.5 acres (approximately 10%) of recovery and injection wells be retained for use as intermediate monitoring wells. Later, a subset of the IMWs will be used as rinse verification wells (RVWs) and closure verification wells (CVWs), as described in the revised BADCT demonstration in the response to comment 16. Figure 16-16 is a conceptual illustration to show the proposed density of the IMWs, CVWs, and RVWs.



Explanation

	Wellfield		Year 9
	Stage 1		Year 10
	Year 1		Stage 2
	Year 2		Year 11
	Year 3		Year 12
	Year 4		Year 13
	Year 5		Stage 3
	Year 6		Year 14
	Year 7		Year 15
	Year 8		Year 16
			Year 17



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Groundwater Flow Model
Gunnison Copper Project
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FIGURE 8-1
Updated Mining
Block Sequence

Particles placed at beginning and end of mining period
(1 day and 365 days) in center of adjoining model cell.

PRELIMINARY DRAFT

Explanation

● Initial Particle Placement

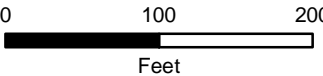
Wells Simulated
(gpm)

- 0
- 3
- 10
- 20

Model Grid

Year 1 83

Wellfield



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FIGURE 8-2
Closure Strategy
Particles and Well Rates
Mining Year 1

Particles are drawn back over 3 years
(from end of mining). Rate is 153 gpm
for each of the three years. All particles
captured within 2.3 years after shutdown.

Explanation

Particle Traces (days)

- 1 - 365
- 366 - 730
- 731 - 1095
- 1096 - 1460

Wells Simulated (gpm)

- ◆ 0
- ◆ 3
- ◆ 10
- ◆ 20

Model Grid

Year 1 Block

Wellfield

Note:
Particle tracks simulated reflect the
regional flow field with no attempt to
control migration. Because the proposed
control strategies involve pullback while
operating, this simulation is considered
very conservative.

0 100 200
Feet

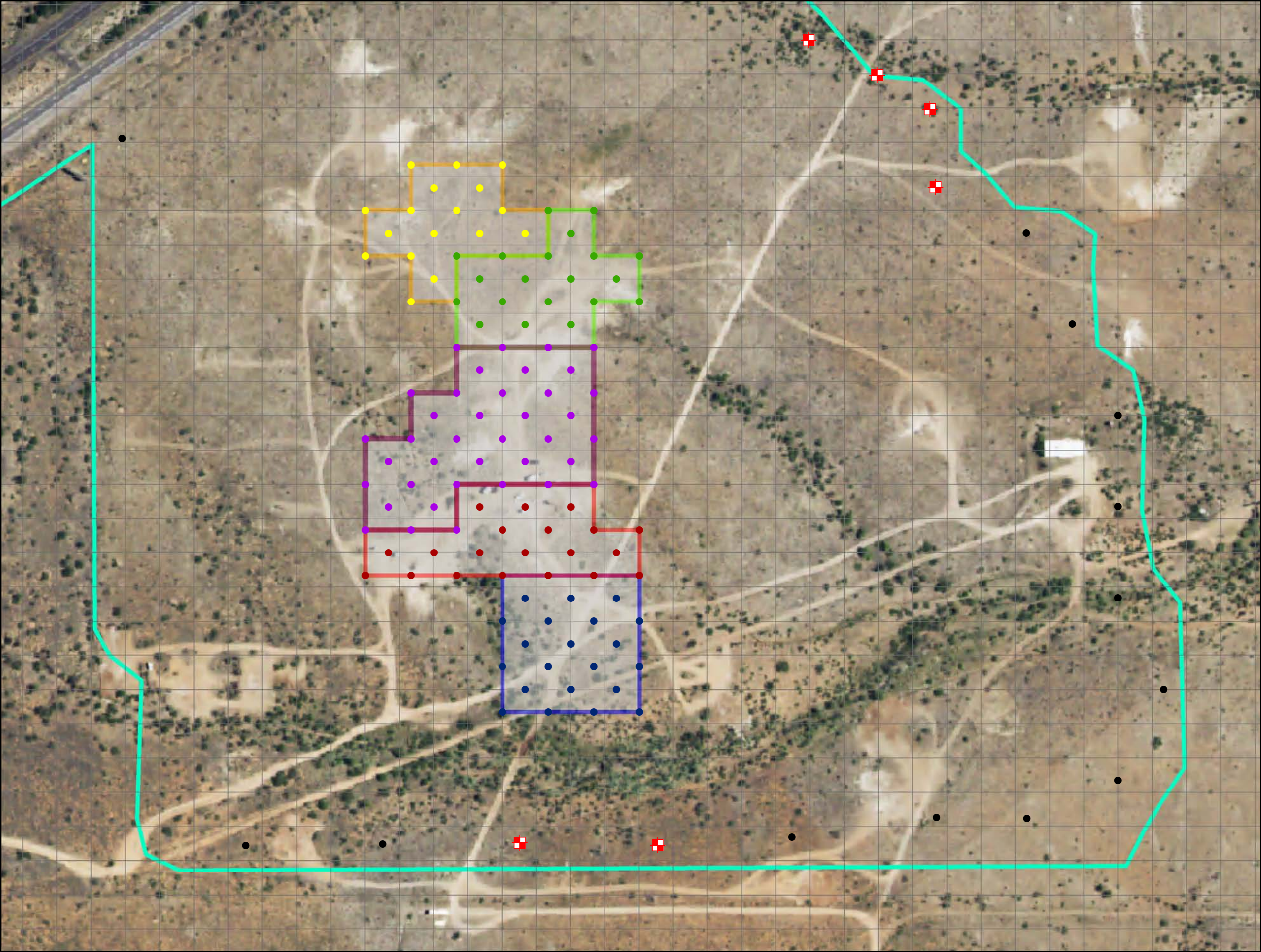
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February 2017

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FIGURE 8-3
Closure Strategy
Containment after Shutdown
Mining Year 1



Explanation

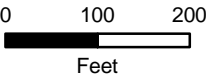
HC Wells for Year 5

- Status**
- Inactive
 - ⊞ Active Year 5

Stage 1 Permit Wells
YEAR

- 1
- 2
- 3
- 4
- 5

- Model Grid
- Year 1 83
- Year 2 83
- Year 3 83
- Year 4 83
- Year 5 83
- Wellfield



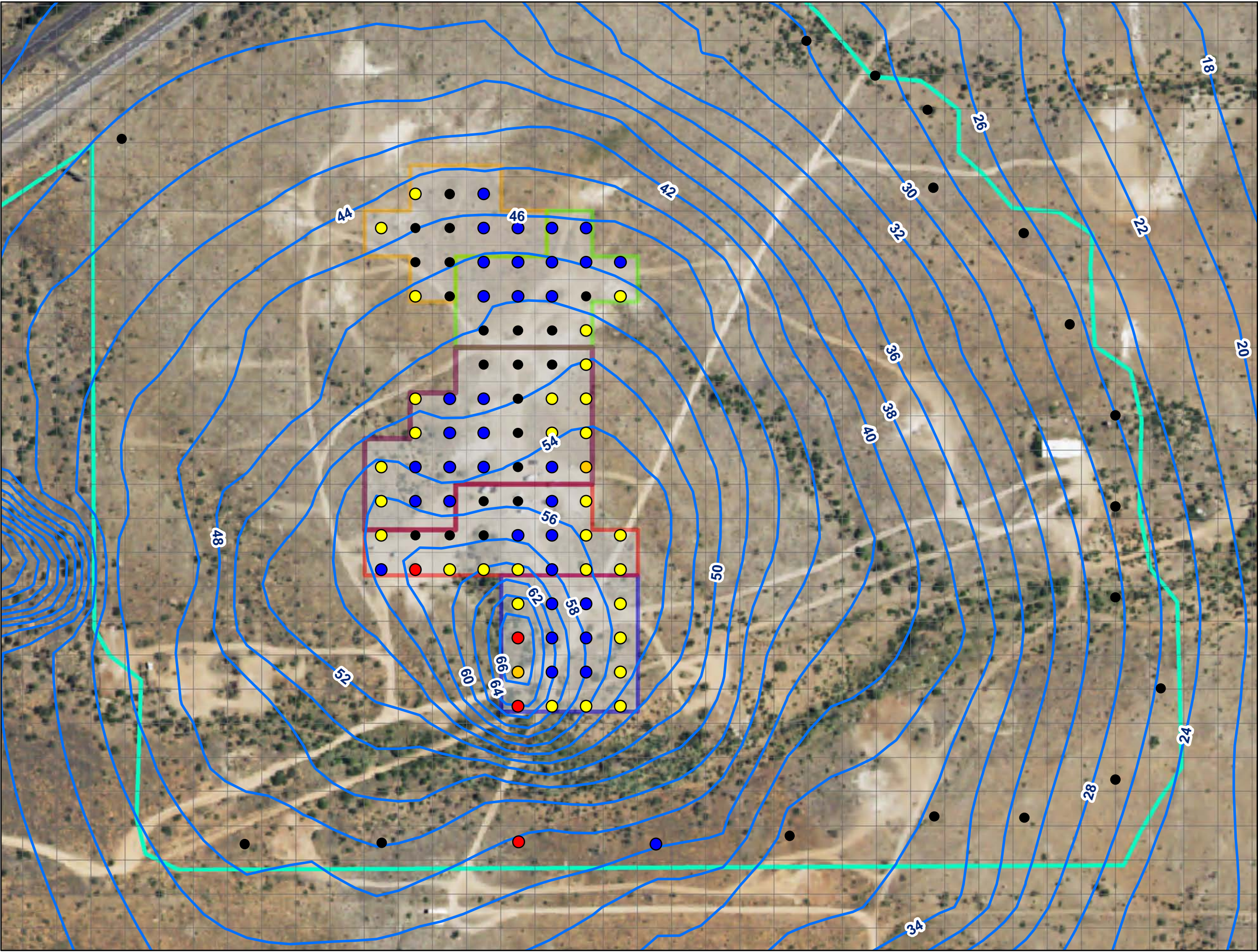
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Gunnison Copper Project
February 2017

Date
2/19/17

File ID
373002



FIGURE 8-4
Closure Strategy
Pumping Rates for Wells
Mining Year 5 Closure

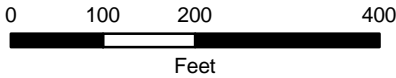


Explanation

**Average Pumping Rate
Years 6-8
(gpm)**

- 0
- 1 - 3
- 4 - 10
- 11 - 15
- 16 - 25

- Layer 3 Drawdown
- Model Grid
- Year 1 83
- Year 2 83
- Year 3 83
- Year 4 83
- Year 5 83
- Wellfield



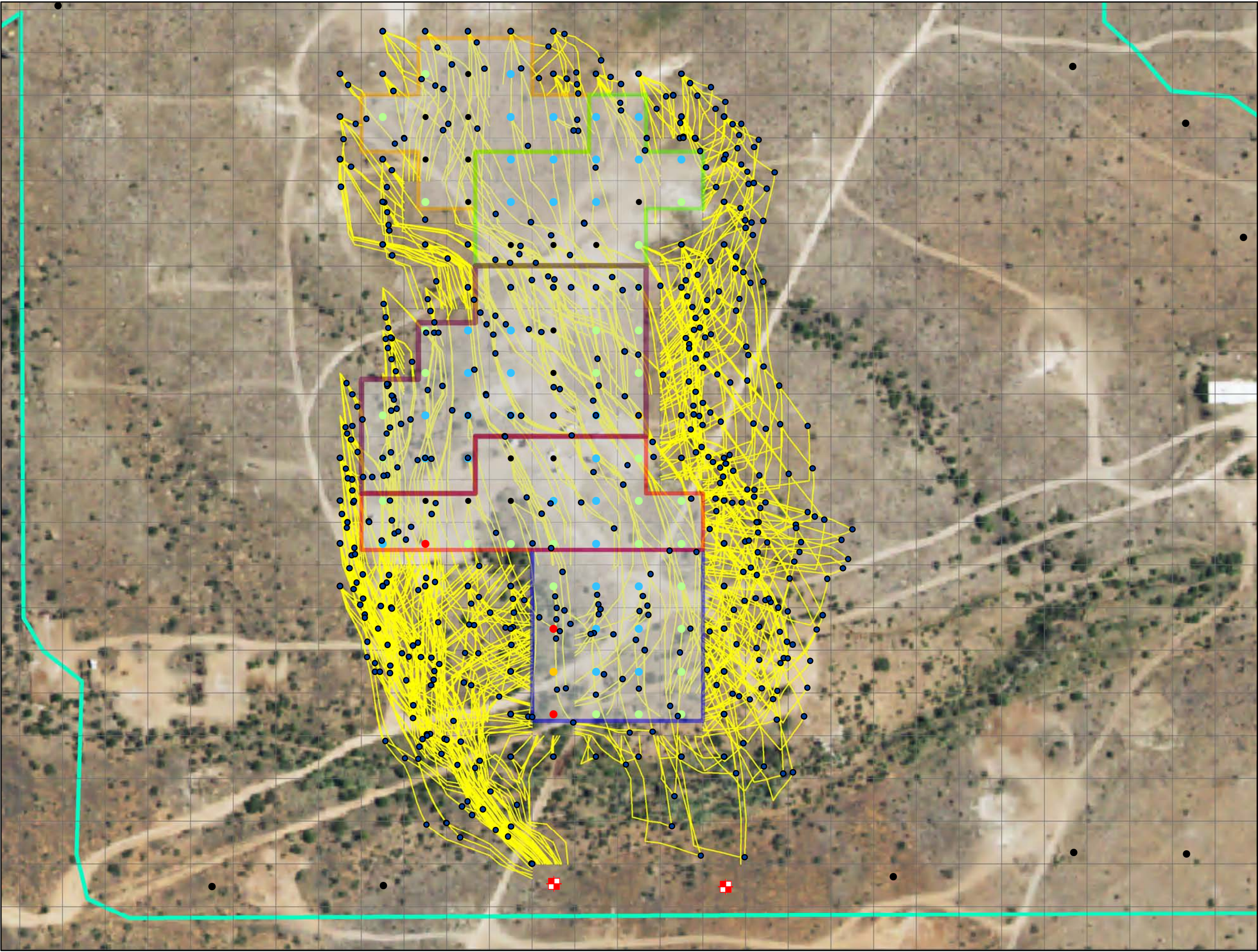
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February 2017

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File ID 373002



FIGURE 8-5
Closure Strategy
Drawdown after Year 8
Mining Year 5 Closure



Explanation

● Particles at Year 5

Average Rate Years 6-8

DefaultQ

- 0
- 1 - 3
- 4 - 10
- 11 - 15
- 16 - 25

HC Wells

- Not Active
- Active

— Particle Traces

■ Year 1 83

■ Year 2 83

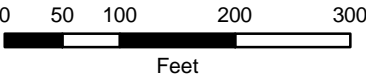
■ Year 3 83

■ Year 4 83

■ Year 5 83

■ Model Grid

■ Wellfield



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FIGURE 8-6
Closure Strategy
Particles Traces
Mining Year 5 Closure

9. Section 5.9 (Process Description and Layout Discharge Impact Area)
The (DIA) indicated by the MODPATH output is shown on Figures 63 and 64 in Appendix I. It is based on the distance traveled by the particles during the 23-year simulation.
- a. *Please revise Figure 64 to show the PMA boundaries in addition to the existing DIA boundaries per A.A.C. R18-9-A202(A)(8)(b)(xii).*

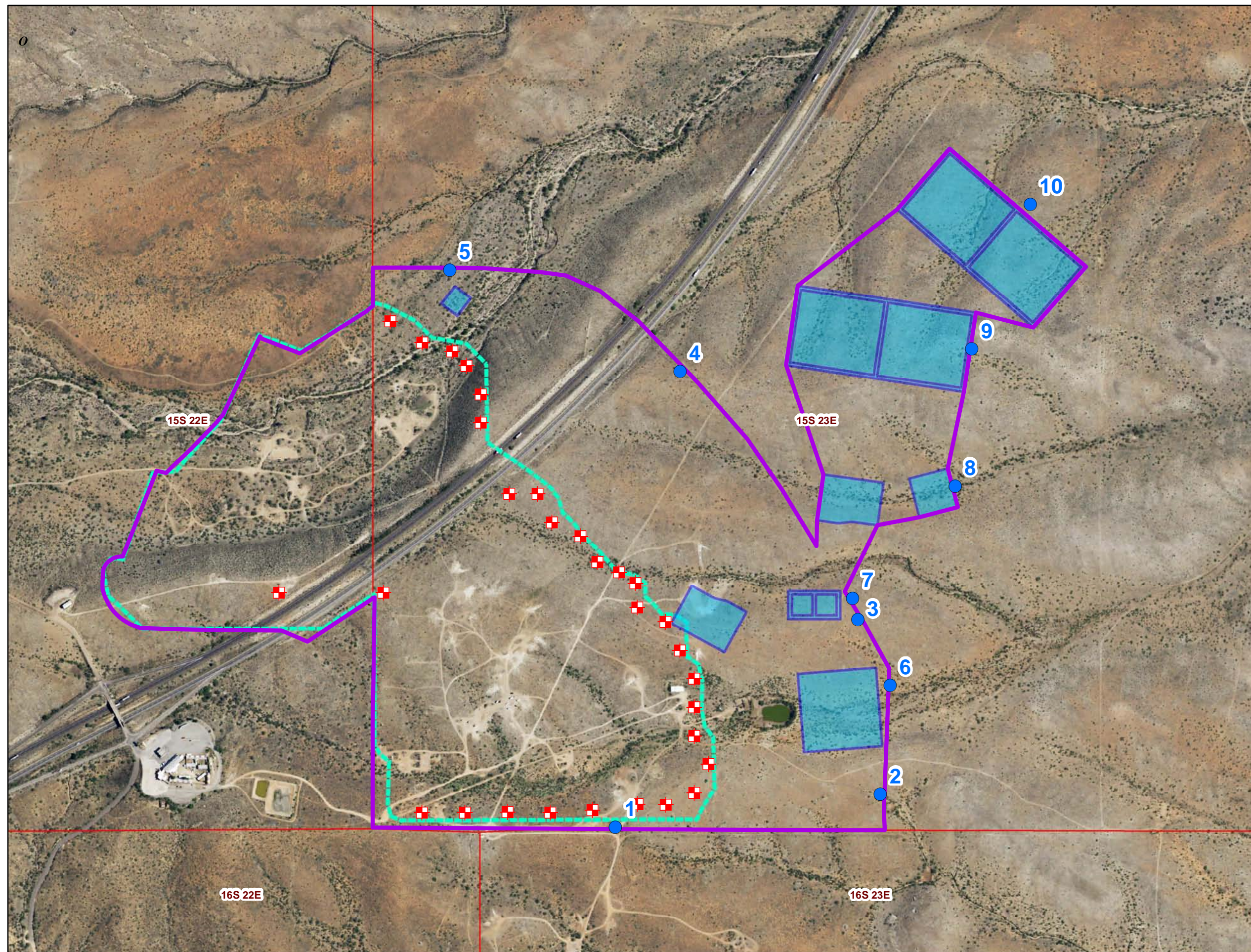
ADEQ Evaluation

The response to RAI 9a is **not** adequate.

Figure 9-1 Revised Discharge Impact Area 23 Year Simulation shows discharge impact areas (DIA) that are not the same as the footprint of the lined impoundments. Please provide a discussion on why the DIA for the lined facilities are showing that there will be releases from those facilities per A.A.C. R18-9-A202(A)(5) and A.A.C. R18-9-A202(A)(8)(b)(xiii).

RESPONSE

Excelsior has revised Figure 9-1 so that the discharge impact areas for the ponds coincides with the footprints. We did not intend to show that there will be releases from the ponds. They will be constructed using prescriptive BADCT and no releases are expected.



Explanation

- Hydraulic Control Wells
- POCs
- PMA and DIA Boundary
- Pond Locations
- Wellfield
- Township



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Groundwater Flow Model
Gunnison Copper Project
February 2017

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FIGURE 9-1
Discharge Impact Area and
PMA Boundary

CRAI Comment

11. *As discussed in Section 1.2.1, production is anticipated to increase in stages.*

Please clarify how the groundwater removal rates increase from one stage to another (both hydraulic control and recovery wells), how would it impact the aquifer per A.A.C. R18-9-A202(A)(8)(b)(iii and iv).

ADEQ Evaluation

The response to RAI 11 is **not** adequate.

Excelsior provided tables of net withdrawal rates, estimated average total pumping rate and estimated maximum pumping rate for the three stages of mining and post production rinsing. ADEQ requests an additional table that clarifies the net withdrawal rates, the estimated amount and rate of water injected and recovered from the mine blocks and the estimated amount and rate of water pumped from the hydraulic control wells.

EXCELSIOR RESPONSE:

The preferred BADCT (presented in the response to comment 16) assumes:

- hydraulic control is always maintained at the perimeter of the wellfield area, and
- that the combination of recovery well pumping and hydraulic control pumping will exceed injection volumes, resulting in a net groundwater withdrawal and the formation of a cone of depression.

The groundwater flow model simulated the net extraction from the pumping of the hydraulic control wells and was calibrated to reflect groundwater flow conditions and capture of particles during operations. The rates calculated for the hydraulic control pumping were specifically set to achieve capture and maintain hydraulic control. The groundwater model incorporates the hydraulic conductivity data from the detailed geologic model, and thus is constructed to assess the impacts on groundwater flow due to the hydraulic control pumping. The following table provides the following for each Stage: Average/Maximum Pumping rates for each stage, hydraulic control pumping (per year) and net withdrawal per year. Please note that the net withdrawal is the same as the hydraulic control pumping because injection will approximately equal extraction.

Stage 1				Stage 2				Stage 3				Post Production Rinsing			
Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control (gpm)	Net Pumping (gpm)	Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control	Net Pumping	Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control	Net Pumping	Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control	Net Pumping
1	5,300 / 6,000	15	15	11	15,800/ 17000	125	125	14	25,600 / 28,000	155	155	21	850/ 1,400	191	191
2		45	45	12		125	125	15		160	160	22		191	191
3		45	45	13		125	125	16		125	125	23		123	123
4		50	50					17		175	175				
5		68	68					18		175	175				
6		82	82					19		191	191				
7		125	125					20		191	191				
8		125	125							191	191				
9		125	125							191	191				
10		125	125												
	AVERAGE		80				125				173				168

Figure 11-1 (provided in Excelsior's September 2016 response to comments) illustrates the drawdown based on the groundwater model simulation at the end of Stage 1 using the net withdrawals shown for Years 1-10. Contours in blue illustrate the drawdown in feet. This figure illustrates a more regional view, showing the drawdown in relation to the Town of Dagoon and the Johnson Camp Mine. The maximum drawdown is approximately 25 feet. Figure 11-2 (provided in Excelsior's September 2016 response to comments) illustrates the drawdown after Stage 2, with a maximum simulated values of over 26 feet. Figure 11-3 (provided in Excelsior's September 2016 response to comments) illustrates the drawdown at the end of Stage 3, with a maximum drawdown of over 40 feet. Generally, the drawdown increases as production increases, since additional hydraulic control wells are added over time.

CRAI Comment**12. Section 1.2.5 (Process Flows)**

Clean water that is needed in excess of the groundwater supplied by the hydraulic control wells will be supplied by water supply wells, the location(s) of which are to be determined.

Please identify the source and quality of the clean water that is needed in excess of the groundwater recovered from the injection/recovery well networks per A.A.C. R18-9-A202(A)(8)(b)(iv).

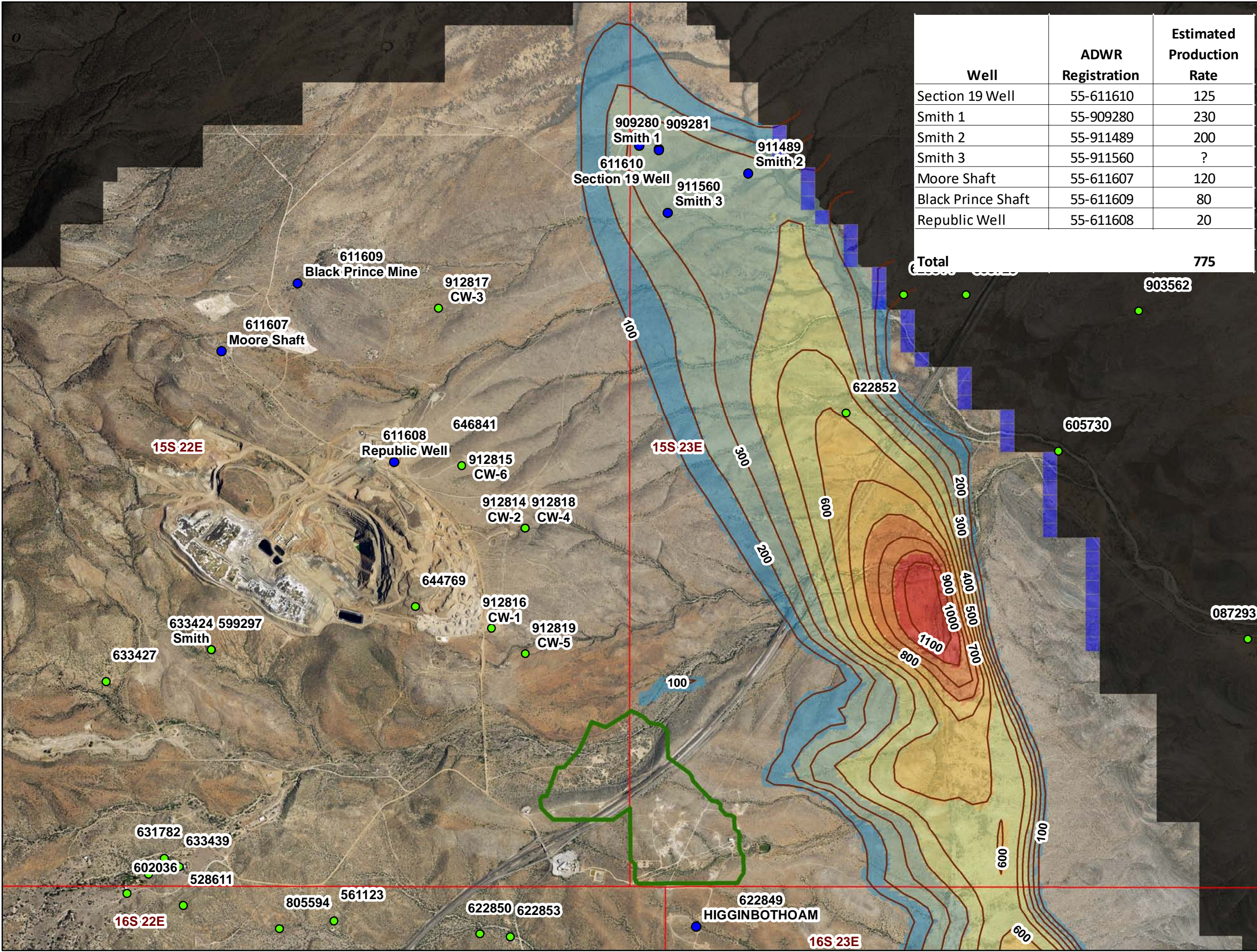
ADEQ Evaluation

The response to RAI 12 is **not** adequate.

Sources of clean water include five potential sources: Johnson Camp Mine (JCM) Section 19 well (55-611610); Smith Well 1 and 2 (55-909280 and 55-911489); Smith Well #3 (55-911560); the Moore Shaft at JCM; and unimpacted water from hydraulic control wells. ADEQ requests that each potential source of clean water be represented on a figure containing the mine blocks. The volume of clean water that may be used from each source should also be provided with a discussion on whether the groundwater flow model included an evaluation of how this pumping may impact capture.

EXCELSIOR RESPONSE:

The attached map shows the potential water sources and estimated production rates. Based on the distances to the project site, they are not expected to impact capture.



Well	ADWR Registration	Estimated Production Rate
Section 19 Well	55-611610	125
Smith 1	55-909280	230
Smith 2	55-911489	200
Smith 3	55-911560	?
Moore Shaft	55-611607	120
Black Prince Shaft	55-611609	80
Republic Well	55-611608	20
Total		775

- Explanation**
- Water Supply Wells**
- EXEMPT
 - NON-EXEMPT
- Basin Fill Saturated Thickness (feet)**
- 100 - 200
 - 201 - 400
 - 401 - 600
 - 601 - 800
 - 801 - 1000
 - 1001 - 1204
- Contours of Saturated Thickness (feet)**
- Constant Heads
 - Wellfield
 - Township
 - Groundwater Model Domain

Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
January 2017

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FIGURE 12-1
Potential Water Supply Wells
near Johnson Camp Mine

14. Section 1.2.5 (Process Flows)

The groundwater produced from hydraulic control pumping will be conveyed to the Clean Water Pond.

Per A.A.C. R18-9-A202(A)(8)(b)(iv and vi):

- a. Please identify the locations of the hydraulic control wells that will be providing clean water to the Clean Water Pond.*

ADEQ Evaluation

The response to RAI 14a is **not** adequate.

The response indicated that the location of the hydraulic control wells was provided in Figure 2-1. This figure did not provide the locations of the hydraulic control wells, only the intermediate NSH monitoring wells. Please clarify the location of the hydraulic control wells and provide the approximate latitude and longitude for each hydraulic control well.

EXCELSIOR RESPONSE:

Excelsior referenced the wrong figure number in the original response. Below is a revised response with strikeouts used to show the revisions.

- a. Locations of hydraulic control wells that will be providing clean water to the Clean Water Pond are shown on Figures ~~2-1~~ 18-1, 18-2, and 18-3 (in our response to Comment ~~2~~18). All of the hydraulic control wells will supply clean water during their initial operating periods. As long as there are no impacts to the water from mining operations, groundwater from the hydraulic control wells will be routed to the Clean Water Pond. If there is evidence that the groundwater will be affected by mining solutions (as described below), it will be routed to the Evaporation pond. Intermediate monitoring wells (i.e. monitor wells located between the mining blocks and the HC wells) will be monitored for pH and specific conductivity as an early warning that impacted groundwater is approaching a hydraulic control well.

Hydraulic control well locations are provided below:

Name	NAD83X	NAD83Y	Lat	Long
HC-01	737741	392801	32.0798408°	-110.0448055°
HC-02	738042	392803	32.0798454°	-110.0438337°
HC-03	738353	392818	32.0798856°	-110.0428295°
HC-04	738656	392861	32.0800029°	-110.0418510°
HC-05	738938	392818	32.0798838°	-110.0409406°
HC-06	739256	392861	32.0800010°	-110.0399137°
HC-07	739454	392858	32.0799921°	-110.0392744°
HC-08	739654	392942	32.0802223°	-110.0386284°
HC-09	739754	393142	32.0807718°	-110.0383047°
HC-10	739654	393342	32.0802223°	-110.0383040°
HC-11	739654	393542	32.0802223°	-110.0383032°
HC-12	739654	393742	32.0802223°	-110.0383024°
HC-13	739554	393942	32.0829716°	-110.0389474°
HC-14	739454	394142	32.0799921°	-110.0389467°
HC-15	739254	394242	32.0837973°	-110.0399149°
HC-16	739241	394413	32.0842674°	-110.0399563°
HC-17	739126	394488	32.0844740°	-110.0403273°
HC-18	738975	394564	32.0846834°	-110.0408146°
HC-19	738854	394742	32.0851731°	-110.0412046°
HC-20	738654	394842	32.0854486°	-110.0418500°
HC-21	738554	395042	32.0859987°	-110.0421722°
HC-22	738354	395042	32.0859994°	-110.0421722°
HC-23	738154	395542	32.0873745°	-110.0434619°
HC-24	738154	395742	32.0873745°	-110.0434612°
HC-25	738054	395942	32.0884744°	-110.0437834°
HC-26	737954	396042	32.0887496°	-110.0441059°
HC-27	737742	396104	32.0889207°	-110.0447902°
HC-28	737518	396255	32.0893365°	-110.0455130°
HC-29	737142	394302	32.0839689°	-110.0467342°
HC-30	737471	394349	32.0840971°	-110.0456717°

15. *The WTP will be designed to produce high density solids during the neutralization of treated water. Addition of lime raises the pH causing the precipitation of metal hydroxides and sulfate minerals. The solids will settle in a clarifier to maximize water recovery and solids density. Clarifier underflow, consisting of precipitates, will be routed to a Solids Impoundment (Stream 20).*

Please provide additional information on the process that will be used in handling the Clarifier underflow, consisting of precipitates per A.A.C. R18-9-A202(A)(5).

ADEQ Evaluation

The response to RAI 15 is **not** adequate.

Excelsior states the solids generated by the water treatment facility (WTF) will be located in a Solids Containment Impoundment which will be double lined facility with leak detection per BADCT. The response does not state what will happen to the brine generated by the reverse osmosis of the solution that is filtered and treated from the WTF. Please state the location of the brine storage per A.A.C. R18-9-A202(A)(3).

EXCELSIOR RESPONSE:

The WTF will be constructed for Stage 2 operations. As shown on Figure 1-4 of the original APP Application, brine will be routed to the Evaporation pond.

16. *A.R.S. 49-243(B)(1) indicates the facility should be “designed, constructed and operated as to ensure the greatest degree of discharge reduction achievable through application of the best available demonstrated control technology (BADCT), technology, processes, operating methods or other alternatives, including, where practicable, a technology permitting no discharge of pollutants.”*

Per A.A.C. R18-9-A202(A)(5)(a)(i) and (b), please provide an alternative BADCT analysis using the process specified in the Arizona Mining BADCT Guidance Manual (BADCT Manual) in Section 1.1.3, Individual BADCT Review Process For New Facilities. As one of the alternatives, evaluate the BADCT discharge control for in-situ leach with deep well injection as per Section 3.4.5.3.1 of the BADCT Manual which indicates that the recovery wells should be pumped at a greater rate than the injection rate. Please note that the volume of fluids recovered should not include the volume of fluids pumped from the hydraulic control wells (i.e. the cone of depression is maintained at the perimeter of the 5-spot groups within the ore body). Note that the BADCT Manual makes no mention of the use of peripheral hydraulic control wells to achieve the recovery rate and establish the cone of depression to contain, capture and recycle solutions. The alternative BADCT analysis must include an evaluation of the discharge reduction achieved for each alternative with the goal of minimizing discharge to the greatest degree practicable as required by A.R.S. 49-243.B.1.

ADEQ Evaluation

The response to RAI 16 is **not** adequate.

While ADEQ accepts the proposed Alternative 1, ADEQ requests the following additional information.

ADEQ has the following comments on Alternative 1.

- a) In Section 7.1.4.2.1 Hydraulic Gradients, it is proposed to use paired observation wells located outside the hydraulic control wells. ADEQ requests that Gunnison evaluate additional lines of evidence to help demonstrate hydraulic control. For example, use of additional wells (intermediate wells), groundwater contour maps, and groundwater chemistry (electrical conductivity) to document hydraulic control. The data collected can be used to further calibrate and refine the numeric groundwater flow model.
- b) Section 7.1.4.2.2 Injection Flow includes the estimated average injection rate and estimated maximum injection rate in gallons per minute (gpm) for Stages 1, 2, and 3 along with post production rinsing. ADEQ requests that Excelsior provide an estimated average and maximum flow rate for each mine block as well as estimated total flow rates that will be included as a discharge limit within the permit if it is appropriate. If not appropriate, please provide a discussion on why a flow discharge limit is not appropriate for this permit.
- c) In the second paragraph of Section 7.1.4.3 Borehole Abandonment it is indicated that Excelsior may abandon some wells and core holes to control flow to the shallow bedrock of “PLS”. Excelsior must provide a description with the criteria as to when a well and/or core hole would be abandoned to prevent migration.

- d) In the sixth paragraph of Section 7.1.5.1 Rinsing Strategy, it is indicated that only 10% of wells within the mining block during the rinsing process will have groundwater monitoring to evaluate effectiveness of rinsing. The list of analytes includes: dissolved metals, sulfate, TDS, pH, VOCs and specific conductivity. Excelsior must provide rationale on how many samples will be collected, including which wells would be sampled. ADEQ recommends a much higher percentage of wells to be sampled or provide a description on why 10% is an appropriate number of wells to be sampled. For example, at February 2, 2017 meeting between Excelsior and ADEQ, Excelsior showed a figure with the 10% of wells represented and indicated that 10% of wells represents a sampling interval of one sample per acre. Based upon the previous sentence, please provide the figure and associated language. Excelsior must discuss how many wells for each mine year closure are to be sampled.
- e) In Section 7.1.6 Post-Closure Groundwater Monitoring, it is proposed to monitor the POC wells for an additional five years annually after rinsing is complete. Excelsior must provide a rationale as to why five years of post-closure monitoring at the POC wells is considered to be adequate. Excelsior must also define when post-closure monitoring is considered to begin. ADEQ recommends that post-closure monitoring to monitor for rebound truly begins once rinsing is complete. Excelsior must also indicate the time frame for post-closure monitoring within the rinsed mine blocks and state why that timeframe was chosen.
- f) Section 7.1.7 Feasibility and Practicability did not include any disadvantages. Excelsior must provide a description on why there are no disadvantages to their chosen alternative.

ADEQ has the following comments on Alternative 3.

- a) In Section 7.2.2 Operational Feasibility, it is indicated that the hydraulic control wells located near the active mine blocks would need to be abandoned as mining advances. This is not necessarily true. The nearby hydraulic control wells could be placed in locations that would allow the hydraulic control wells to be repurposed as injection/recovery wells for a mine block. Additionally, these hydraulic control wells would provide valuable hydrogeologic information to help with the configuration of future mine blocks. This discussion should be included in the evaluation.
- b) Section 7.4.4 Summary Table provides an evaluation of the following parameters: Degree of Aquifer Loading; Practicable and Economically Achievable; Demonstrable; Water Resource Conservation; Technical Advantages; and Technical Disadvantages. Under Degree of Aquifer Loading, the response states the reference BADCT alternative, Alternative 1, provides the lowest loading, due to all solutions being contained due to the hydraulic control wells. This is not entirely accurate. Alternative 1 provides the most dilution of any escapes from the mine blocks, not limiting loading. Excelsior must remember that the bedrock is a drinking water aquifer under A.R.S. § 49-202 and is the sole source of drinking water in the area. So any escape from the mine

block should be considered aquifer loading and be evaluated as such. Based upon the comments provided above for Alternative 1 and Alternative 3, the summary table should be revised.

Excelsior provided three alternatives discussed below, and proposed to use Alternative 1.

- Alternative 1, referred to as the Reference Alternative, is the same as that provided in the original application.
- Alternative 2 evaluates pumping of recovery wells within the mining blocks at a greater rate than the injection rate in order to maintain a cone of depression (as required by BADCT manual).
- Alternative 3 involves pumping and injection at approximately equal amounts and pumping from hydraulic control wells near the perimeters of the active blocks within the wellfield.

Alternative 1

The response indicated that Alternative 1 presented in Section 7.1 of the original APP application, was generally unchanged. However, they specifically stated that some of the ore body occurs within the unsaturated zone and in order to leach those areas above the water table, the “leaching solution must be mounded”. Average injection rates were provided for each Stage (not per well) in Section 7.1.4.2.2. Excelsior proposed a maximum injection pressure (Section 7.1.4.2.3) of 0.75 psi/ft (measured daily) to prevent hydraulic fracturing and propagation of existing fractures.

Section 7.1.7 Feasibility and Practicability is also new. A few of design advantages listed in this revised section are provided below.

- They propose to minimize drawdown within the wellfield to maximize ore extraction below the water table. They propose to have equal injection/recovery within the mining blocks while providing hydraulic control around the perimeter to the south and east.
- They propose to create a mound within a block (or do they intend to raise the water table within the wellfield?) to extract the unsaturated ore above the water table.
- Excelsior expresses concern about extraction of hydraulic control water for Alternatives 2 and 3 as quoted below:
 - “Alternate pumping schemes that extract hydraulic control water from within or directly adjacent to the active mining area will produce PLS or PLS-impacted waters that cannot be used for rinsing or makeup water. This water will require additional treatment and disposal, thus increasing the area of land that must be disturbed to construct additional evaporation and solids containment pond.”
- Excelsior indicated as one of the advantages of Alternative 1 as being “Operationally feasible. It will not be necessary to re-pipe hydraulic control

wells to change them to injection/recovery wells (as in the case of Alternative 3). This reduces the chances for accidental releases by digging up an active wellfield.”

Alternative 2

Alternative 2 varies from Alternative 1 only in operational controls – specifically hydraulic gradients of discharge. There will be no dedicated hydraulic control wells. All other aspects are pretty much the same as that for Alternative 1. A significant drawback to this alternative is that it will result in partial dewatering of the ore body and thus a loss of access to a portion of the mineral resource. Another disadvantage cited was that there would be a need for additional treatment and disposal capacity (see Alternative 1 advantages above and table presented in Section 7.4.4 on page 7-21).

Excelsior expressed concern over partial dewatering of the ore body and thereby loss of access to a portion of the ore body. “To simulate net extraction from the wellfield, the overall injection rate was multiplied by 0.03 to account for 3% excess pumping. This rate was spread across all of the active model cells (for each Mining Block). The individual blocks were assigned a rate of $0.03 \times \text{Total Injection Rate} / \text{Number of Active Wells per stress period}$, thus simulating the pumping as broadly spread over the active mining area.”

The simulation drawdown were estimated to be 23 feet after 5 years, 39 feet after 10 years, 99 feet after 13 years, and 91 feet after 16 years.

Excelsior indicated the following on page 7-18:

“To evaluate hydraulic containment for this alternative BADCT, particles were placed around each of the mining blocks, in the next model cell outward from the simulated 3% net-pumping in each block. This simulation was conducted because even with recovery rates that are 3% greater than injection rates, preferred flow pathways could allow particles to escape the active mine block.”

Alternative 3

In this alternative, recovery volumes from around each mine block will exceed injection volumes, creating a broad cone of depression in the wellfield. “However, due to concerns with operational feasibility, this approach was not evaluated with the groundwater model”.

Excelsior discussed logistical challenges of this alternative due to introduction of operation complexities and increased possibility of accidental releases, and difficulties in relation to installing, connecting, and abandoning recovery wells used for hydraulic control around each mining block (see Section 7.3.2, page 7-19).

EXCELSIOR RESPONSE:

Pertinent portions of the BADCT demonstration have been revised to address issues raised by ADEQ above.

AQUIFER PROTECTION PERMIT APPLICATION GUNNISON COPPER PROJECT COCHISE COUNTY, ARIZONA

Revised Section 7.0—Evaluation of BADCT Alternatives

*Provided in response to Item 16 in ADEQ's Comprehensive Request for Additional Information
dated June 17, 2016*

Revised April 2017

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WELLFIELD BADCT

Excelsior Mining Inc. prepared this revised Section 7 of the Aquifer Protection Permit (APP) Application for the Gunnison Copper Project. Section 7, the Wellfield BADCT demonstration, was revised in response to ADEQ's comment #16 in a letter dated June 17, 2016. Section 7.1 of this document is generally unchanged from the original APP submittal. Sections 7.2, 7.3 and 7.4 are new. Figures in the original APP application may be referred to in this text. New figures (designated with a prefix of "16-") were prepared to respond to ADEQ's comment 16 and can be found at the end of this text.

A.R.S. § 49-243(B)(1) requires that an APP-regulated facility "be so designed, constructed, and operated as to ensure the greatest degree of discharge reduction achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives".

This document presents three BADCT alternatives for the wellfield:

- Alternative 1, the Reference Alternative, is the alternative presented in the original APP application dated January 2016. It involves pumping and injection within the wellfield at approximately equal amounts and pumping from hydraulic control wells at the perimeter of the wellfield to create overlapping cones of depression to contain solutions within the wellfield.
- Alternative 2 follows a suggested discharge control in which recovery wells within the mining blocks are pumped at a greater rate than the injection rate in order to maintain a cone of depression. There are no hydraulic control wells at the perimeter of the wellfield.
- Alternative 3 involves pumping and injection at approximately equal amounts and pumping from hydraulic control wells near the perimeters of the active blocks within the wellfield.

According to A.R.S. 49-243(B)(1), in determining BADCT, processes, operating methods or other alternatives, "the director shall take into account any treatment process contributing to the discharge, site specific hydrologic and geologic characteristics and other environmental factors, the opportunity for water conservation or augmentation and economic impacts of the use of alternative technologies, processes or operating methods on an industry-wide basis." In the case of In-Situ Recovery (ISR), geologic characteristics play a significant role in what can be achieved and what can be demonstrated.

ADEQ's BADCT Guidance Manual (2004) provides guidance for three types of in-situ leaching:

1. Deep well injection within an ore body below the water table.
2. In-situ leaching using the water table for capture.
3. In-situ leaching with capture above the water table.

While most of the ore at the Gunnison Copper Project is below the water table, some of the ore is above the water table. Thus, the project is a hybrid of leaching methods 1 and 2 above.

7.1 Wellfield BADCT—Alternative 1 (Reference Design)

The Project will consist of in situ recovery by deep well injection and recovery. This BADCT demonstration includes the following elements:

- Site characterization
 - Climate and surface hydrology
 - Subsurface characterization
 - Geologic hazards and stability design
- Site preparation
- Surface water control
- Discharge control
- Operational measures
- Closure/post-closure

7.1.1 Site Characterization

Climate and surface hydrology are discussed in Section 4 of this APP application.

Characterization of the geology and hydrogeology is discussed in Sections 3 and 5. A groundwater modeling report is provided in Appendix I of the APP Application. Because no changes have been implemented in the hydraulic control pumping schedule since the APP was submitted, the figures for drawdown and head contours have not changed. However, the proposed sequence and location of the mining blocks have been altered since the original submittal. Revised Figure 18-1 (in the response to Comment 18) illustrates the updated sequence of mining blocks for the reference BADCT. Revised figures 8-3, 8-4 and 8-5 (in the response to Comment 8), illustrate the particle tracking from each mining block for each year of mining. As noted, the hydraulic control pumping rates have not changed, but particle starting locations were updated to reflect the revised mining block sequence.

The risk from geologic hazards is minimal. The topography of the Project location is not conducive to landslides. Subsidence is unlikely to occur, due to the absence of large-scale groundwater withdrawals or any significant water level declines in area. Settlement due to loading is not applicable. In-situ recovery elements will not be located in any areas subject to significant loading. Earthquake-induced ground failures are not likely to occur. There are no active faults located within the Project, and conditions associated with liquefaction (as listed on page 3-43 of Arizona Mining BADCT Guidance Manual [ADEQ, 2004]) are absent. Additional details are provided in Sections 3.6 and 3.7. Collapsing soils do not pose a risk to the in-situ operations, as all injection will occur into deep bedrock and soils will not be wetted as part of the in situ recovery operations.

7.1.2 Site Preparation

Minimal site preparation will be necessary for construction of the wellfield. It will consist mostly of typical ground-clearing and grading activities necessary for well drilling operations. Hydrofracturing will not be implemented.

7.1.3 Surface Water Control

As noted in the Arizona Mining BADCT Guidance Manual (ADEQ, 2004), surface water control systems “may be minor” where ISR operations use injection wells. Solution application will not occur at the surface, thus limiting the potential for mingling of process solution and precipitation. Significant surface water management structures such as diversion channels, dams, or retention basins are not planned for the wellfield. Cement seals between the well casing and the borehole wall will prevent migration of surface water down the annulus of the wells. Wells will not be installed in drainages that could compromise their integrity.

7.1.4 Discharge Controls

The Arizona Mining BADCT Guidance Manual (ADEQ, 2004) states that the objective for discharge controls is to effectively control leach solution, and that site specific factors are used to determine the amount of engineered control that is required. Geologic features such as low permeability zones and attenuation can be used as effective sub-surface containment.

7.1.4.1 Site Specific Characteristics

Site specific factors that play a role in maintaining control of the leach solution are:

- Absence of a USDW (as defined by 40 CFR §144.3) overlying the zone of injection. For the most part, alluvium above the ore body is unsaturated or the saturated thickness is limited.
- Absence of an USDW (low hydraulic conductivity sulfide ore body) underlying the zone of injection.
- Large attenuation capacity of limestone within and downgradient of the zone of injection.

Each of these characteristics is discussed in the sections below.

7.1.4.1.1 Unsaturated Basin Fill

The absence of a significant thickness of saturated basin fill overlying the proposed ISR wellfield is a favorable site specific characteristic for maintaining discharge control. Excelsior's UIC application will not request an aquifer exemption for the basin fill because the basin fill does not meet the definition of an USDW according to 40 CFR §144.3. Occurrences of saturated basin fill are thin and isolated above the ore deposit; thus, it does not contain a "sufficient quantity of groundwater to supply a public water system."

Observations regarding groundwater in basin fill are discussed in Section 5.5.2. Specifically, the following observations regarding saturated alluvium (or lack thereof) have been documented:

- 1) The absence of saturated basin fill within the area that will be encompassed by the ISR wellfield was documented by Haley & Aldrich (Appendix F) during their hydrogeologic investigation of the Project. Haley & Aldrich oversaw and documented the drilling and installation of 21 hydrogeologic wells and 5 piezometers in 2014-2015 (Figure 2 of their report in Appendix F). Saturated basin fill was not observed in any of the boreholes within the ISR wellfield area during this drilling campaign. Groundwater was encountered in bedrock fractures, in most cases more than 20 feet below the basin fill-bedrock contact. After well completion in the bedrock, groundwater rose into the cased section of three wells (NSH-014B, NSH-016, NSH-009), above the elevation of the basin fill-bedrock contact. The groundwater levels in the completed wells represent a potentiometric surface, indicating confined conditions within the bedrock aquifer; they do not indicate the actual depth to the saturated interval, if present.
- 2) In 2011-2012, saturated basin fill was identified in two boreholes within the wellfield. Four alluvial monitoring wells were planned during the 2014-2015 drilling program, but one well was dry, and three were not completed due to lack of saturated basin fill encountered during drilling of nearby bedrock wells. The two wells in which saturated basin fill have been identified within the wellfield are:
 - a) NSH-006, which is screened within basin fill. Haley & Aldrich (Appendix F) indicated that this well had 40 feet of saturated basin fill; recent water levels indicate approximately 30 feet of saturation at this well.
 - b) NSD-020, which had 30 feet of saturated basin fill at the time of installation.

Both of these wells are within an isolated low spot on the bedrock surface that appears to be constrained by the 4,200-foot bedrock surface contour (Figure 5-13 in the APP application). A bedrock ridge on the east side of the 4,200-foot bedrock surface elevation contour serves as a barrier to downgradient migration of groundwater that is present in the basin fill west of the ridge.

The general lack of saturated basin fill and the presence of unsaturated bedrock within the ore body is a site characteristic that has direct bearing on the mining method. (The potentiometric surface in relationship to the bedrock surface is shown on Figure 5-12 in the APP application). Some of the ore body occurs within the unsaturated zone. In order to leach those areas of

bedrock above the water table, leaching solution must be mounded within the active mine block in order to reach the ore.

7.1.4.1.2 Low Conductivity Sulfide Zone

The bedrock sulfide zone is located beneath the zone of injection. The sulfide zone is less fractured than the oxide zone. Excelsior conducted two aquifer tests, at NSH-014B and NSH-025, in the sulfide zone in 2015. Both tests were terminated before the scheduled end because the wells were pumped dry. A complete analysis of the aquifer testing data is provided in Appendix G. Drawdown in NSH-014B was 442 feet after 1.5 hours at a pumping rate of one gpm. The estimated hydraulic conductivity for NSH-014B is .001 ft/day. Drawdown in NSH-025 was 220 feet after one hour with pumping at a rate of four gpm. The estimated hydraulic conductivity in NSH-025 is 0.1 ft/day. Both hydraulic conductivity values are very low. Because of its low hydraulic conductivity, the sulfide zone is not feasible as an aquifer for a public water supply, and it provides a site specific control on the vertical migration of injected solutions.

7.1.4.1.3 Attenuation Capacity of Limestone

The regional hydraulic gradient (Figure 5-10 in the APP application) indicates that if hydraulic control around the ISR wellfield were to be lost, the PLS would migrate in an eastward direction. As shown on Figures 3-5 and 3-7 in the APP application, the Escabrosa and Horquilla limestones are located east of the mineralized rocks. These formations are predominantly composed of calcite with some minor subordinate clastic and dolomitic beds in the Horquilla and a dolomitic layer at the base of the Escabrosa (Cooper and Silver, 1964).

As discussed in Appendix J.1, geochemical modeling by Duke HydroChem demonstrates that the attenuation capacity of these limestones is a significant discharge control. According to Duke HydroChem, “the neutralization reaction occurs very quickly with pH of the solution reaching circumneutral within approximately one day. As the pH approaches circumneutral, metal concentrations are controlled by precipitation of secondary mineral phases and through sorption on the surface of secondary hydrous ferric oxide (HFO) precipitates.”

7.1.4.2 Operational Controls

7.1.4.2.1 Hydraulic Gradients

ADEQ’s Mining BADCT Guidance Manual (2004) identifies pumping to create a cone of depression as an accepted discharge control design element for in situ recovery with deep well injection. Excelsior’s strategy for controlling solutions is to install hydraulic control (HC) wells that will generate overlapping cones of depression, where needed, around the perimeter of the wellfield.

Numerical groundwater flow (MODFLOW) and particle track (MODPATH) modeling of the Project (Appendix I) have shown that this approach will be successful in providing hydraulic capture and control of the solutions. The model was constructed using aquifer parameters that were consistent with the results of numerous long-term aquifer tests conducted at the Project (Appendix G). The model simulations were based on the assumption that over the duration of the Project, the total rate of pumping from the ISR wells and hydraulic control wells will be adjusted and maintained to exceed the total rate of lixiviant injection.

In accordance with the model findings, Excelsior will install hydraulic control wells and observation wells around the wellfield (Figure 7-1 in the APP application). The well locations are approximate¹; the actual locations may vary slightly and will be determined by site-specific conditions and the progression of in situ mining activities. Installation and startup of the hydraulic control wells will proceed in approximate concurrence with the development and startup of each ISR wellfield block. The hydraulic control wells will be installed and operated downgradient from areas of the ISR wellfield as those areas become active, as indicated by Figure 18-1.

The hydraulic control wells and observation wells will be screened (or open) at approximately the same elevations as the injection and recovery wells. The hydraulic control wells will supply water to the Project and generate cones of depression which will provide an outer hydraulic barrier around the in-situ recovery operations. The observation well pairs will be located outside the hydraulic control wells and will be used to monitor the inward hydraulic gradients generated by the hydraulic control wells. At this time, it is anticipated that 30 hydraulic control wells are needed to maintain inward gradients and hydraulic capture. Excelsior plans to install observation well pairs at 11 of the hydraulic control wells. Numerical modeling has shown that hydraulic control wells are not needed on the western side of the wellfield due to the natural west-to-east hydraulic gradient across the Project, with the exception of two locations where modeling indicated a localized southward flow direction. Hydraulic capture is discussed further in Appendix I.

Evidence of inward gradients in fractured rock aquifers can be demonstrated at the fixed hydraulic control wells using paired monitor wells. The fixed location of the monitoring points allows for testing and evaluation to determine whether the wells monitor regional changes in hydraulic conditions, rather than localized conditions subject to the vagaries of the fracture network. Once the testing demonstrates the regional nature of the hydraulic conditions, long-term monitoring can effectively show the maintenance of inward hydraulic gradients.

¹ It should be noted that the hydraulic control well locations are sited at the scale of the model grid size, which is 75 feet square. It is anticipated that locations may vary slightly based upon the site specific conditions (i.e. slopes, obstacles, etc.) or other conditions encountered during drilling. However, the general layout of hydraulic control wells will remain the same, and locations listed are close to the final locations for the project.

To provide additional data demonstrating hydraulic control, Excelsior will prepare groundwater contour maps, for inclusion in annual APP monitoring reports, to document hydraulic containment of the wellfield around the active blocks. Water levels from intermediate monitoring wells and observation wells will be used to construct the map. Groundwater chemistry (specific conductivity), will also be evaluated as an indicator of hydraulic control. The data will be used to refine the numeric groundwater flow model as it is periodically updated.

7.1.4.2.2 Injection Flow

Injection rates and volumes will depend on a number of factors including:

1. The number of active injection wells (either in production, rinsing, or conditioning),
2. The rate at which the injection zone can accept lixiviant,
3. The rate at which recovery wells can be pumped.

Injection will include conditioning, leaching and rinsing operations. According to Excelsior's production schedule, the number of active Class III injection wells is anticipated to range from fewer than 20 in Year 1 to approximately 450 in Year 17. Therefore, over the life of the project, there will be considerable variation in the injection volumes.

The following table provides the following for each Stage: Average/Maximum Pumping rates for each stage, hydraulic control pumping (per year) and net withdrawal per year. Please note that the net withdrawal is the same as the hydraulic control pumping because injection will equal extraction.

Stage 1				Stage 2				Stage 3				Post Production Rinsing			
Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control (gpm)	Net Pumping (gpm)	Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control	Net Pumping	Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control	Net Pumping	Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control	Net Pumping
1	5,300 / 6,000	15	15	11	15,800/ 17000	125	125	14	25,600 / 28,000	155	155	21	850/ 1,400	191	191
2		45	45	12		125	125	15		160	160	22		191	191
3		45	45	13		125	125	16		125	125	23		123	123
4		50	50					17		175	175				
5		68	68					18		175	175				
6		82	82					19		191	191				
7		125	125					20		191	191				
8		125	125							191	191				
9		125	125							191	191				
10		125	125												
	AVERAGE		80				125				173				168

The actual field conditions encountered during operation will determine the pumping and injection rates. Compliance with a specific net volume or net rate of extraction in excess of injection is not proposed as a permit condition, as it is expected to vary depending on the block(s) being mined and rinsed. Excelsior plans to operate the wellfield as a whole, not as individual blocks. Therefore, setting flow rates for each block is also not practical. Depending on PLS grades, rates will need adjustments up or down.

The proposed permit conditions regarding injection flow are as follows:

- total injection, production, and hydraulic control volumes will be monitored and recorded daily;
- the 30-day rolling average of the total volume of injected fluids will not exceed the 30 day rolling average of the total volume of pumping from recovery wells and hydraulic control wells;
- an inward hydraulic gradient will be maintained around the active portions of the ISR wellfield, as measured in observation wells located near the hydraulic control wells (Figure 5-16 in the APP application).

7.1.4.2.3 Injection Pressure

Fracture gradient testing conducted in 2015 (29 packer tests in six formations) resulted in fracture gradients ranging from 0.78 to 2.22 pounds per square inch per foot (psi/ft). Details of the testing methodology and analyses are provided in Appendix N of the APP Application. Excelsior proposes a conservative maximum injection pressure gradient of 0.75 psi/ft to prevent hydraulic fracturing and propagation of existing fractures, to be measured daily.

7.1.4.3 Borehole Abandonment

ADEQ's Mining BADCT Guidance Manual (2004) and 40 CFR §144.55 identify plugging and abandonment of potential conduit wells and boreholes as a "corrective action" under UIC and as an appropriate BADCT element for ISR with deep well injection projects. Because neither the basin fill above the oxide ore body nor the sulfide zone underlying it meet the definition of an USDW according to 40 CFR §144.3, well and borehole abandonment is not proposed as a permit requirement or an element of BADCT. Some existing coreholes within the wellfield closure may be used as water level monitoring points within the wellfield.

Prior to leaching in each mine block, Excelsior will plug and abandon pre-existing wells and coreholes. As mining blocks progress, any coreholes or boreholes in a new mining block that are not constructed to Class III requirements, will be abandoned before mining of that block begins. In these cases, plugging or abandonment of the boreholes will be conducted as described in below, using a method consistent with the "Standard Abandonment Method" in the ADWR Well Abandonment Handbook (2008).

The following tasks will be completed when well and borehole abandonment is conducted:

1. Inspect and Document Well or Borehole: The well or borehole will be inspected from the surface. The condition will be documented and recorded and the site will be photographed.
2. Remove Equipment: Equipment including pumps, wiring, tubing, and transducers will be removed from the well. Any equipment that cannot be retrieved will be documented.
3. Determine if Borehole is Obstructed and Measure Water Level: An electric sounder will be used to determine the water level and depth of the borehole. The measured depth will be compared to drilling records to determine if the borehole is open to the bottom or if it is obstructed. The depth will be recorded and evidence of obstruction will be noted.
4. Casing/Screen:
 - a. PVC Well Casing: In some cases, PVC casing and well screen are hanging in the borehole from a clamp in the wellhead. No annular materials were installed. If it is possible to remove the casing and screen in these wells (i.e. the formations have not collapsed around the PVC), it will be removed from the borehole prior to plugging. NSH-7, NSH-10 and NSH-16 are examples of wells that are constructed in this manner, but there may be others. Should additional wells be

identified with this construction, they will be plugged and abandoned using the same methodology.

- b. Low Carbon Steel (LCS) Casing: Many of the coreholes have LCS casing installed to the bedrock contact and are open boreholes beneath that depth. If the casing is not grouted to the surface with cement or high solids bentonite grout it will be perforated. The casing will be perforated from 50 feet above the water level (measured in Step 3) to the total depth of the casing.
- c. In wells where there is casing in which the annular space was grouted during installation, or if there is no casing at all, the borehole will be grouted from the bottom to at least two feet below grade as described in the next section.

Each well or borehole will be filled as completely as possible with Type V neat cement using the following procedure:

1. The area around the well will be cleared and the surface casing will be cut at two or more feet below grade. Cement or steel resulting from cutting casing will be removed from the site.
2. Tremie pipe will be installed to within 20 feet of the bottom of the well. In wells that are determined to be obstructed during preparation, the contractor will try to push the tremie pipe through the obstruction. If the tremie cannot be installed through the obstruction, the contractor will try to install drill pipe through the obstruction. If both of those options fail, the well will be abandoned from the obstruction to the surface.
3. Type V cement will be installed through the tremie pipe with the end of the tremie pipe below the top surface of the cement to ensure that there are no gaps in the cement seal. The cement will be installed under enough pressure to fill voids in the borehole wall and casing.
4. The site will be levelled and the borehole will be covered with soil.

Field personnel will record types and quantities of materials used and emplacement depths of each material. Each site will be photographed after completion and covering of the borehole. Copies of field data and the forms described below will be maintained at the Project site for inspection until closure is completed.

Following the plugging and abandonment of existing or injection wells, reports will be filed with state and federal agencies as described below.

ADWR: Within 30 days of the completion of plugging and abandonment the drilling contractor will submit a Well Abandonment Completion Report (Form 55-58) to ADWR. Within 30 days of completion of plugging and abandonment Excelsior or their designee will submit a Well Owner's Notification of Abandonment (Form 55-36).

USEPA: Excelsior will report plugging and abandonment activities in the quarterly monitoring reports sent to the USEPA Director. The plugging and abandonment will be included in the quarterly report for the quarter in which the activities were completed.

Reporting data will include an updated version of Form 7520-14 and copies of the forms sent to ADWR described above.

ADEQ will receive copies of the reports submitted to ADWR and USEPA.

7.1.4.4 Well Construction

ADEQ's Mining BADCT Guidance Manual (2004) provides criteria for injection well construction. The criteria are based on UIC requirements for Class III Wells.

Wells installed at the Project will include injection, recovery, hydraulic control, observation wells, and POC monitoring wells. With the exception of the POC monitoring wells, these wells will be constructed to meet Class III requirements². Several possible well designs, including varying diameters, are planned for the injection, recovery, and hydraulic control wells. The injection, recovery, and hydraulic control wells are proposed to have open-hole completions within the ore body, which ranges from approximately 50 to 1250 feet in thickness. Observation wells and POC wells will be constructed with well screen. Proposed well constructions are as shown on Figures 7-2 through 7-4 in the APP application. Additional details are provided in the sections below.

7.1.4.4.1 Surface Seal

The annulus between the borehole wall and the uppermost 20 feet of the well casing will be sealed with cement grout. The surface casing will be consistent with the materials (FRP, PVC, or LCS) discussed in Section 7.1.4.4.3 below. Excelsior will request a variance from the ADWR, pursuant to AAC R12-15-811 and R12-15-820, to allow the surface casing to consist of materials other than steel, if appropriate.

During drilling, if necessary, an outer temporary steel surface casing (LCS manufactured in accordance with ASTM Specification 153-89A Grade A or better) will be installed to support the ground surface. The temporary steel casing will be of sufficient diameter to allow for drilling of the borehole (Section 6.2.4.4.2) and installation of the permanent well casing (Section 7.1.4.4.3) and annular seal (Section 7.1.4.4.4). It will be driven to a minimum depth of 20 feet to maintain borehole stability during drilling. The minimum length of the temporary surface casing will be 21 feet, to allow for a minimum 1-foot stickup above land surface. The temporary surface casing will be removed after drilling is complete and prior to installation of the cement grout seal at the surface.

² POC wells will be located just outside the PMA and the "Area of Review" delineated in the UIC Application, and therefore Class III requirements do not apply.

7.1.4.4.2 Borehole

Boreholes will be drilled using air rotary, direct mud rotary, reverse circulation mud rotary, or casing advance drilling methods. The wells will be drilled in two stages: the upper stage will consist of a boring drilled from land surface through basin fill into competent bedrock or 20 feet below the bedrock surface, whichever is greater. After the casing for the first stage is cemented in place, a smaller diameter borehole will be drilled into the bedrock to total depth. In most cases, the borehole within the bedrock interval will remain open. If boreholes are found to be unstable, screen may be installed in the bedrock section to keep the borehole open. Annular materials in the screened interval are not proposed.

Borehole diameters will be sufficient to allow for installation of casing that will accommodate the pumps. The cased portions of the boreholes will be 12-inch nominal (small diameter injection/recovery wells and hydraulic control wells), 15-inch nominal (large diameter injection/recovery wells), and 10-inch nominal (observation and POC wells). The open borehole sections within bedrock will be 5- and 7-inch nominal.

7.1.4.4.3 Casing

Casing strings (including the well screen if the well has a screened completion) will be of appropriate size and grade to have sufficient collapse, pressurization, and tensional strengths to maintain integrity during well construction and for the life of the well. Well materials will be compatible with injected fluids and formation fluids with which they are expected to come into contact.

Casing materials to be used include FRP, LCS, and Schedule 80 PVC. Each of these materials provide certain advantages, and a well may have more than one type of casing; for example, as shown on Figures 7-2 and 7-3 in the APP application, PVC may be used in the upper part of the borehole above the cement seal and FRP casing may be used in the lower grouted section. Alternatively, FRP may be used throughout. Or, as shown on Figure 7-4 in the APP application, LCS casing may be used above FRP casing; in this case a packer will be used to isolate the lixiviant so that it comes in contact with the FRP section only.

Casing centralizers will be placed every 40 feet along the casing (and screen, if used) length. The casing string will be suspended in the borehole until the annular materials are installed.

7.1.4.4.4 Annular Materials

Under §146.32 of the federal UIC regulations, Class III wells must be cased and cemented to prevent the migration of fluids into or between USDWs. The cemented interval of each well annulus will be required to pass a mechanical integrity test as defined by the USEPA (Section 7.1.4.4.5).

As described in Section 7.1.4.1.1, there is no viable aquifer above or below the injection zone. This absence of a USDW indicates that the risk associated with migration of fluids is significantly reduced within the Project wellfield. Nevertheless, Class III wells will be cased and cemented to maintain control of fluids within the wellfield.

Prior to cementing, suitable mud-dispersing chemicals will be circulated if needed to assist in the removal of drilling mud from the annulus and to promote bonding between the casing, cement, and formation. Cement will consist of sulfate-resistant Portland Type V cement.

The casing annulus of all Class III wells will be grouted to 100 feet above the basin fill/bedrock contact (or static groundwater level, whichever is shallower). The grout will be pumped through a grout pipe inside the casing, which is fitted with a drillable cementing shoe (or float shoe), and raised above the bottom of the borehole. The cementing shoe has a backpressure valve, which prevents grout from backing up into the casing when the grout pipe is removed. The grout is forced around the bottom of the casing and upward in the annular space. The grout pipe is then detached from the cementing shoe and raised to the surface. After the required setting time, the cementing shoe is drilled out and the work on the well continued. The cement grout will be allowed to cure for 24 hours prior to resumption of drilling.

Clean fill will be installed from the top of the cement to 20 feet below the ground surface using a tremie pipe. Then the surface casing will be removed and the annulus from 20 feet to the ground surface will be filled with cement grout.

7.1.4.4.5 Mechanical Integrity Testing

After well construction is complete, Part 1 of the UIC mechanical integrity testing requirement will be addressed by the following method or another suitable method approved by ADEQ and USEPA: A packer will be installed immediately above the bottom of the cased interval, and the casing will be completely filled with water. A hydraulic pressure equal to or above the maximum allowable wellhead injection pressure will be applied. The test will be conducted for a minimum of 30 minutes. The well will be considered to have passed if there is less than a five (5) percent change in pressure during the 30 minute period. Part 1 mechanical integrity will be demonstrated before a Class III well is put into service and when there is reason to suspect a well failure, as described in the Contingency Plan (Section 9).

If the packer completion (Figure 7-4 in the APP application) is used, mechanical integrity testing of the tubing-casing annulus pressure will be conducted according to UIC requirements.

Part 2 mechanical integrity testing addresses vertical channels adjacent to the well bore; it will not be conducted because the basin fill that overlies the injection zone is not a USDW.

7.1.5 Wellfield Closure Strategy

Excelsior will comply with the requirements of AAC. R18-9-A209(B) prior to formal closure. A complete APP Closure Plan will be submitted by Excelsior in advance of closure of APP-regulated facilities in accordance with permit requirements.

Closure of the wellfield will include rinsing to remove residual PLS and well abandonment, as discussed in the sections below. The closure strategy consists of the following elements:

- Rinsing
- Well plugging and abandonment
- Report preparation
- Post-Closure Monitoring

7.1.5.1 Rinsing Strategy

A rinsing closure strategy is proposed for the wellfield. After copper recoveries drop below the economic cutoff, ISR in a given production block will be deemed complete and the block will be rinsed using fresh groundwater until applicable water quality standards are met. A flow chart that summarizes the closure strategy is provided as Figure 16-15.

Based on geochemical modeling by Duke HydroChem (Appendix J.1), the following 3-step rinsing strategy is proposed:

1. Rinse three (3) pore volumes (based on a 3% fracture porosity of the ore body)
2. Rest
3. Rinse two (2) pore volumes

Step 1 will result in a mix of 5% PLS and 95% groundwater after rinsing with three pore volumes, based on core tray and column testing documented in a rinsing report by Clear Creek (Appendix J.2). The mechanism by which solute is removed during Step 1 is advective flow, i.e. flushing of the fractures.

Step 2 allows the solution to be neutralized as silicate and carbonate minerals are altered. Solute concentrations will be controlled by precipitation of secondary minerals and complexation (sorption) on hydrous ferric oxide surfaces. The resting period will continue until pH of the resident solution is circumneutral and all regulated constituents are at or below AWQSSs. The geochemical model results indicate that these conditions would be attained after a resting period of approximately one year (Appendix J.1).

Step 3 is a final rinse of two pore volumes. This step will facilitate removal of any constituents that might still be present at or near regulatory limits. Similar to Step 1, the solute removal mechanism of Step 3 is flushing.

To get to final closure, the following steps (which are also shown on the flow chart—figure 16-15) will be taken:

- Monitoring of groundwater from the mining block after rinsing will be conducted to evaluate the effectiveness of the rinsing. Samples will be collected from approximately 10% of the wells within the mining block after step 3, representing approximately 1 well for every 1.5 acres of the wellfield (figure 16-16). These wells (approximately 1 well per 1.5 acres) will be designated the “Rinse Verification Wells” (RVWs). The RVWs will remain open and available throughout the mine life to assist with closure verification and post rinse remediation if required. Analyses will be conducted for APP-regulated metals (dissolved), sulfate, TDS, pH, VOCs³ and specific conductivity. Excelsior will select these wells based on their spatial, geological, hydrogeological, and geochemical representativeness. Only recovery wells will be sampled, as rinsed injection wells will not be representative of the bedrock groundwater chemistry. If analyses indicate that AWQSS or MCLs are not achieved in the block, rinsing and/or resting will resume.
- When AWQSS and MCLs are achieved in the RVWs, the remaining (non-RVW) wells in the mining block will be plugged and abandoned, leaving only the RVWs which represent approximately 1 well per 1.5 acres.
- An appropriate number (a subset) of RVWs will be selected as post-rinse IMWs, the location and distribution of which will be determined using the general principles outlined in Excelsior’s response to comment 2. Their purpose is to identify possible migration of mining fluids from adjacent active mining areas back into previously-rinsed mining blocks. These IMWs will be continuously monitored for water elevation and specific conductivity. A post-rinse ambient specific conductivity level for the RVWs will be set as an AL that is indicative of compliance with AWQSS and MCLs, based on empirical data (“post-rinse AL”) gathered during previous monitoring.
- In the event of increasing specific conductivity above the ALs in the IMWs, Excelsior will implement the following response(s):
 - Continued monitoring to establish neutralization capacity and/or
 - Adjust operations to reverse the trend (pull back solutions) and/or
 - Adjust nearby rinsing operations to reverse the trend

³ Excelsior proposes to use the full EPA 8260B analyte list for VOC analyses, as listed in the EPA Method.

- When an area is to be closed because it is the end of the mine life or there is no future mining planned adjacent or up-gradient, a subset of the RVWs will be identified (approximately 1 well every 13.5 acres as shown on Figure 16-16). These wells will be designated as “Closure Verification Wells” or CVWs. Samples from these wells will be analyzed by laboratory methods for APP-regulated metals (dissolved), sulfate, TDS, pH, VOCs and specific conductivity. When all CVWs in an area meet AWQS or MCLs then applicable hydraulic control wells will be turned off (but not abandoned).
- To determine if later rebound above AWQS or MCLs has occurred, monitoring of CVWs will continue once per year until 5 consecutive years of CVWs meeting AWQSs and MCLs has occurred. If in any year AWQSs or MCLs are not met in a particular area, appropriate HC wells can be turned back on and additional pumping, rinsing or resting of CVWs and/or adjacent RVWs can occur.
- When all CVWs have met AWQSs and MCLs for five consecutive years, monitoring will stop and all wells (RVWs, CVWs, HC, Observation and POC) will be plugged and abandoned.

Prior to well plugging and abandonment of a mining block, a report will be submitted to ADEQ documenting the rinsing and monitoring data. The report will include documentation of the volumes of rinse water injected and recovered, results of laboratory analytical analyses after Step 3, and a recommendation will be provided on whether additional rinsing is needed. Well plugging and abandonment will not commence without approval from ADEQ and USEPA. As discussed above, approximately 1 well every 1.5 acres will be designated as Rise Verification Wells (RVWs), a subset of which will become either post-rinse IMWs or later Closure Verification Wells (CVWs) and will not be abandoned until the end of the life of mine, to allow for monitoring as described above.

Well rinsing costs for Stage 1 operations are provided in revised Appendix M (provided in the response to comment 49 submitted to ADEQ on September 1, 2016).

7.1.5.2 Well Plugging and Abandonment

After the goals of the rinsing are met, the wells in the wellfield, which are classified as Class III injection wells under the UIC regulations, will be plugged and abandoned, as required under 40 CFR 146.10. This requires that wells be abandoned in such a way that fluid will not move into USDWs. In addition to the federal requirements, AAC R12-15-816 contains abandonment requirements and additional guidance is provided in the ADWR Well Abandonment Handbook

(ADWR, 2008). The handbook states that the abandonment of a well be accomplished “through filling or sealing the well so as to prevent the well, including the annular outside casing, from being a channel allowing the vertical movement of water.”

Class III Well plugging and Abandonment procedures will be similar to those described in Section 7.1.4.3.

Following the plugging and abandonment of Class III injection/recovery wells, reports will be filed with state and federal agencies as described below.

ADWR: Within 30 days of the completion of plugging and abandonment the drilling contractor will submit a Well Abandonment Completion Report (Form 55-58) to ADWR. Within 30 days of completion of plugging and abandonment Excelsior or their designee will submit a Well Owner’s Notification of Abandonment (Form 55-36). The forms are included as Exhibit B.

USEPA: Excelsior will report plugging and abandonment activities in the quarterly monitoring reports sent to the USEPA Director. The plugging and abandonment will be included in the quarterly report for the quarter in which the activities were completed. Reporting data will include an updated version of Form 7520-14 and copies of the forms sent to ADWR described above.

ADEQ: Will receive copies of all documentation of plugging and abandonment activities that are sent to ADWR and USEPA.

7.1.6 Post-Closure Groundwater Monitoring

Geochemical modeling (Appendix J.1 and Section 7.1.5.1) has shown that AWQSs will be achieved after rinsing. Post closure monitoring will be conducted as summarized in the Section 7.1.5.1. Because Excelsior intends to rinse until MCLs and AWQSs are achieved within the wellfield, monitoring at the POCs will not be conducted. Rather, post-closure monitoring will be conducted the selected CVWs within the wellfield for 5 years..The samples will be collected annually, according to the methodology prescribed in the permit. Costs for post-closure monitoring are provided in the revised Appendix M.

Excelsior has proposed that when AWQS and MCLs are achieved for five (5) successive years, post closure monitoring can be terminated and the remaining wells (monitoring, hydraulic control, POC) can be abandoned.

7.1.7 Feasibility and Practicability

Construction of the wellfield using the reference design is fairly straightforward. Injection and recovery wells are installed in “blocks”. Each well is connected to a header house in the center of

the block by underground piping. Injection wells can be switch to recovery (and vice versa) by switching the piping connections within the header house and installing/removing pumps. There is no need to dig up and re-run piping. The dedicated downgradient hydraulic control wells form a fixed barrier to flow. There is no need to move hydraulic containment as the wellfield expands. Hydraulic control pumping can be turned on or off as the areas of mining progress.

The Reference design advantages include:

- Minimizing drawdown within the wellfield, thus maximizing the amount of ore below the water table. This is achieved through approximately equal injection/recovery within the mining blocks while providing hydraulic control around the eastern and southern boundaries of the wellfield. The hydraulic control pumping results in an overall net withdrawal and drawdown, but the location of the drawdown on the eastern and southern portions of the wellfield is in a more favorable location for optimizing copper recovery.
- Where ore occurs above the water table, the design allows for localized mounding within a block to expose unsaturated ore to leaching solution, while maintaining hydraulic control around the wellfield.
- Establishing a single downgradient hydraulic control system that will be used for the life of the wellfield will provide long-term monitoring data that will allow for an evaluation of data trends. It can be designed (and tested) to demonstrate inward hydraulic gradients.
- Conserving the groundwater resource and reducing area of land disturbance. Pumping from a fixed location at a down-gradient distance from the active mining area greatly reduces the volume and concentration of impacted hydraulic control water. Therefore hydraulic containment water can be used for other purposes around the operations. Alternate pumping schemes that extract hydraulic control water from within or directly adjacent to the active mining area will produce PLS or PLS-impacted waters that cannot be used for rinsing or makeup water. This water will require additional treatment and disposal, thus increasing the area of land that must be disturbed to construct additional evaporation and solids containment pond capacity.
- Operationally feasible. It will not be necessary to re-pipe hydraulic control wells to change them to injection/recovery wells (as is the case in Alternative 3). This reduces the chances for accidental releases by digging up or around an active wellfield. Operating heavy equipment to dig up and re-pipe hydraulic control wells in a wellfield with closely-spaced wells and a network of already buried pipes could result in damage and spills.
- Hydraulic containment water will be of suitable quality for rinsing for most of the project.
- Can demonstrate control using field measurements.

- Easy adjustability by adding more wells if necessary and adjusting pumping rates
- Internal monitoring of TDS can be conducted in monitor wells as early warning of PLS-impacted solutions.
- Reduces size needed for surface evaporation ponds and water treatment facilities
- Groundwater flow modeling shows particle capture.
- Operational flexibility.

A disadvantage of the reference design is that it is not as simple to operate as a wellfield with a fixed ratio of injection to recovery. A separate hydraulic control pumping system adds another level of engineering complexity to the operation of the wellfield and add additional monitoring of observation wells that demonstrate the inward gradient.

7.2 Wellfield BADCT—Alternative 2

Alternative 2 differs from Alternative 1 only in the operational controls—specifically hydraulic gradients of discharge. All other aspects of BADCT (site characterization, site preparation, surface water control, other discharge controls, and closure/post closure) are the same as Alternative 1.

7.2.1 Hydraulic Gradients

ADEQ’s Mining BADCT Guidance Manual (2004) identifies pumping to create a cone of depression as an accepted discharge control design element for in situ recovery with deep well injection. Under Alternative 2, recovery volumes from each mine block will exceed injection volumes by 3%, creating a broad cone of depression in the wellfield. The hydraulic model completed for the Reference Alternative BADCT demonstration was also used to assess this alternative. The 3% rate was determined based on the results of the model simulations for 1, 2 and 3 percent excess pumping. It was determined that 3% excess pumping was necessary to achieve a reasonable containment of the mining blocks. The simulations run at 1% and 2% were unsuccessful at achieving capture. These results are discussed in Section 7.2.3.

7.2.2 Feasibility and Practicability

Construction of the wellfield for Alternative 2 is fairly straightforward. Injection and recovery wells are installed in “blocks”, as illustrated in Figure 16-1. Each well is connected to a header house in the center of the block by underground piping. Injection wells can be switched to recovery (and vice versa) by switching the piping connections within the header house and installing/removing pumps. There is no need to remove and reinstall piping. There will be no

dedicated hydraulic containment wells. Hydraulic containment will be achieved by pumping the extraction wells at a rate 3% greater than the injection rate. A significant drawback to this alternative is that it will result in partial dewatering of the ore body and thus a loss of access to a portion of the mineral resource.

7.2.3 Simulation of Alternative 2

The effect of this BADCT alternative in the wellfield area was simulated in the groundwater model by pumping from each model cell within the active mining blocks for each year. Figure 16-1 illustrates the currently proposed sequence of mining blocks, listed by the first year the block is actively mined. The figure also illustrates an example of well pumping for Mining Year 5. To simulate net extraction from the wellfield, the overall injection rate was multiplied by 0.03 to account for 3% excess pumping. This rate was then spread across all of the active model cells (for each Mining Block). The individual blocks were assigned a rate of $0.03 \times \text{Total Injection Rate} / \text{Number of Active Wells per stress period}$, thus simulating the pumping as broadly spread over the active mining area.

Figure 16-2 illustrates the drawdown in the wellfield after 5 years of operation. Active mining is illustrated by the simulated net withdrawal wells shown in blue. Blocks for Years 2 through 5 are active with pumping at a net of 115.2 gallons per minute (gpm), which is 3% of the proposed injection rate. The maximum simulated drawdown after 5 years of operations exceeds 23 feet.

Figure 16-3 illustrates the drawdown in the wellfield after 10 years of operation, or the end of Stage 1. Active mining is illustrated by the simulated net withdrawal wells shown in blue. Blocks for Years 7 through 10 are active with pumping at a net of 113.7 gallons per minute (gpm). The maximum simulated drawdown after 10 years exceeds 39 feet.

Figure 16-4 illustrates the drawdown in the wellfield after 13 years of operation, or the end of Stage 2. Active mining is illustrated by the simulated net withdrawal wells shown in blue. Blocks for Years 10 through 13 are active with pumping at a net of 307.8 gallons per minute (gpm). The maximum simulated drawdown after 13 years exceeds 99 feet.

Figure 16-5 illustrates the drawdown in the wellfield after 16 years of operation, or at the period of maximum injection. Active mining is illustrated by the simulated net withdrawal wells shown in blue. Blocks for Years 13 through 16 are active with pumping at a net of 565.0 gallons per minute (gpm). The maximum simulated drawdown after 16 years exceeds 91 feet⁴.

Based on the large drawdown simulated, this control method would have very negative impacts on the available ore reserve, dewatering a significant fraction of the reserves. The effects of

⁴ The maximum drawdown decreases despite increased overall pumping due to the hydraulic conductivity being higher in the areas pumped during this period.

drawdown on the available ore reserve was investigated by Excelsior and is discussed further in Section 7.4.2.

To evaluate hydraulic containment for this alternative BADCT, particles were placed around each of the mining blocks, in the next model cell outward from the simulated 3% net-pumping in each block. This simulation was conducted because even with recovery rates that are 3% greater than injection rates, preferred flow pathways could allow particles to escape the active mine block. Figure 16-6 illustrates the situation for Mining Year 5. Active wells are noted in blue, while particle starting points are presented as red dots. Particles were added for each mining year, around the active mining blocks for that period. The particles were then simulated through the remainder of the 23 year period.

Figure 16-7 illustrates the particle tracking results for the 23 year mining period. Generally, the model results indicate that particles are contained within the wellfield area. However, several particles exit the southern boundary in the southwest portion of the wellfield, and appear to have escaped the containment pumping. Figure 16-8 illustrates a close up view of this area, showing the escaped particles. Based on these results, additional containment pumping would be needed to assure capture.

Figure 16-9 illustrates the particle tracking for 1% excess pumping from the wellfield. Particles are not contained along the south and east portions of the wellfield. This indicates that extraction exceeding production by 1% is inadequate to contain mining operations. Figure 16-10 illustrates the particle tracking for extraction exceeding production by 2%. Although there are fewer escapes, the mining area is not contained fully, with particle escapes on the south and east sides of the wellfield area. These results indicated 3% overpumping was necessary to achieve capture in the wellfield area, although some excursions may occur, based on Figures 16-7 and 16-8.

7.3 Wellfield BADCT—Alternative 3

Alternative 3 includes balanced injection and recovery within the mine block with hydraulic control pumping immediately downgradient of each mine block. Alternative 3 differs from Alternative 1 only in the location of the operational controls—specifically the hydraulic control wells are placed around the perimeter of the mining blocks. All other aspects of BADCT (site characterization, site preparation, surface water control, other discharge controls, and closure/post closure) are the same as Alternative 1.

7.3.1 Hydraulic Gradients

ADEQ's Mining BADCT Guidance Manual (2004) identifies pumping to create a cone of depression as an accepted discharge control design element for in situ recovery with deep well injection. Under Alternative 3, recovery volumes from around each mine block will exceed injection volumes, creating a broad cone of depression in the wellfield. However, due to

concerns with operational feasibility, this approach was not evaluated with the groundwater model, as is described in the following section.

7.3.2 Operational Feasibility

Alternative 3 poses significant logistical challenges that should be considered because they introduce operation complexities and increase the possibility of accidental releases. This alternative incorporates a set of hydraulic control wells placed downgradient of the active mining block. Each year, as new blocks come online, hydraulic control wells are added downgradient of the active mining blocks. These wells would be used until displaced by the active blocks or abandoned as the wellfield develops. These wells will be immediately downgradient of active mining, and it is assumed that they will extract PLS, or significantly impacted groundwater. Because the alternative requires more pumping than injection, the water pumped must be discarded as a contaminated waste; there is no possibility of using the water for any other purpose.

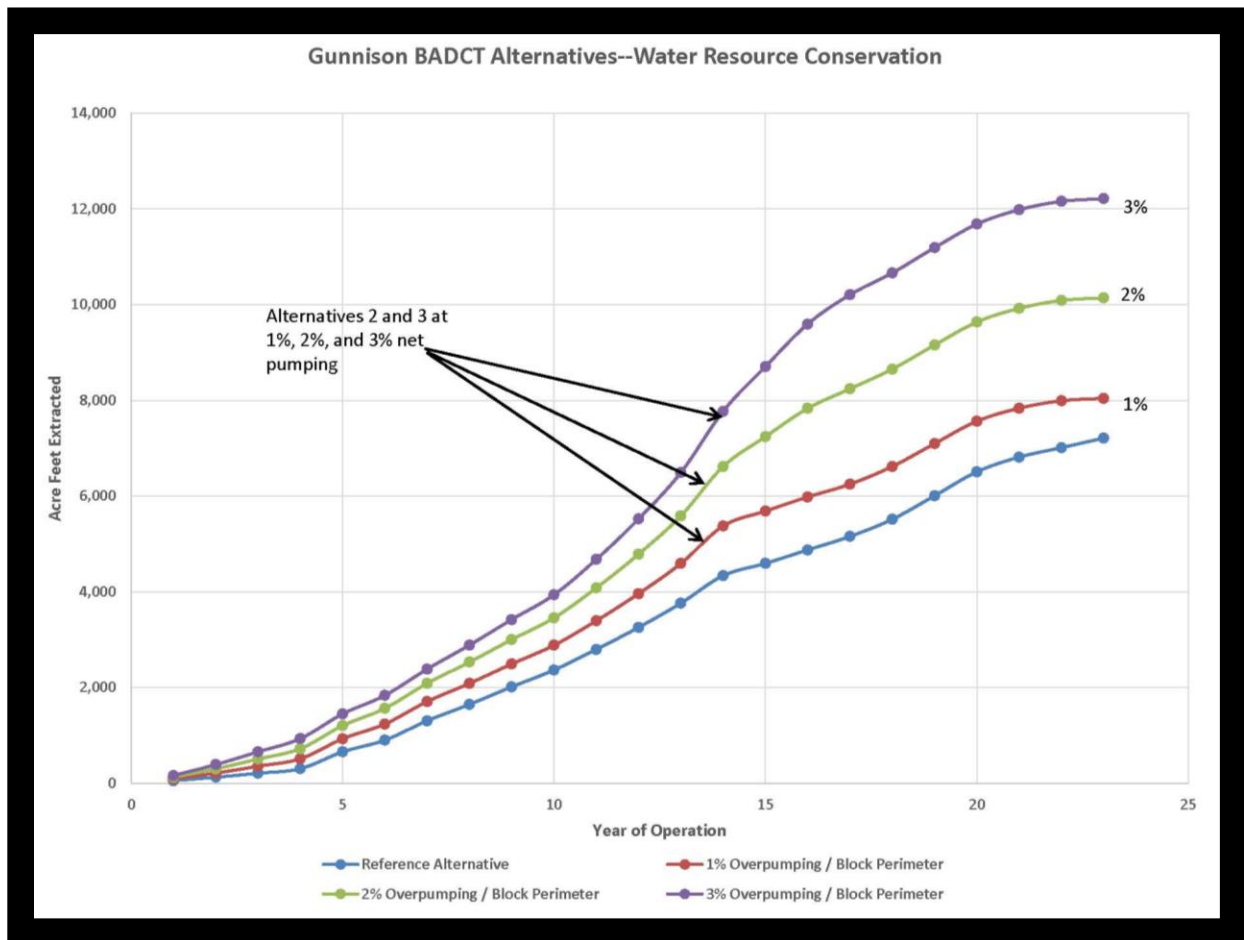
Another difficulty will be the logistics of installing, connecting, and abandoning recovery wells used for hydraulic control around each mining block. Figures 16-11 through 16-14 illustrate the difference between Alternative 3 (Figures 16-11 and 16-12) and the preferred alternative (Figures 16-13 and 16-14). Mining will progress in a continuous fashion with mining blocks. Hydraulic control wells would need to be installed around a mining block before mining begins (Figure 16-11). This would necessitate construction of a separate header house for the hydraulic control wells. As mining in a block is completed, mining will move to a new mining block (Figure 16-12). If the new mining block is adjacent to the old mining block, the hydraulic control wells will need to be repurposed and new wells installed outside of the new mining block. This will necessitate abandonment of pipelines and reconfiguration of header house connections. These adjustments and changes become more complex as mining proceeds. The constant adjustment of pipelines, header houses, and wells is extremely inefficient to the mining operation and increases the likelihood of an inadvertent spill via a broken pipeline. Also, because the process will result in impact of groundwater being pumped for hydraulic control, there will be a loss of the groundwater resource for higher use purposes. This process will also dewater the area around each block, which would result in lower water levels and decreased ore reserves.

In contrast, the reference alternative (Alternative 1), is more efficient because the hydraulic control wells are located along the perimeter of the mining area which avoids the problem of converting and/or abandoning wells as mining progresses. Figures 16-13 and 16-14 illustrate the smooth progression of mining in Alternative 1.

7.4 Discussion and Alternative Selection

7.4.1 Water Resource Conservation

The graph below shows the water consumption of the various BADCT alternatives, based on Excelsior's production schedule. The reference BADCT uses approximately 7,000 acre-feet during the 23 year mine life. Increasingly greater amounts of water are used for Alternatives 2 and 3—depending on whether 1%, 2%, 3% overpumping rates are used. Alternatives 2 and 3, using a recovery rate that is 3% greater than the injection rate, results in over 12,000 acre-feet of water consumption during the 23-year mine life.



7.4.2 Practicability and Economic Achievability

Except for pollutants addressed in §49-243 subsection I, “practicability” (as defined in 49-243.D) includes “economically achievable on an industry-wide basis.” Excelsior does not propose to discharge pollutants included in section 49-243.I.

Alternatives 2 and 3 result in significant dewatering of the ore zone, resulting in loss of mineral resource. Alternative 1 is the BADCT with the highest economic achievability. This consideration (i.e. availability of mineral resource to mining) is a fundamental element of all in-situ mining operations. Excelsior estimates that dewatering the ore reserve by 100 feet will reduce recoverable copper by 180,675,229 pounds, with an economic impact of approximately \$316 Million (after considering operating costs). Implementing BADCT Alternatives 2 or 3 is not a feasible or practicable option for the Gunnison Copper Project.

7.4.3 Aquifer Loading

The three BADCT alternatives involve injection of the same volumes of fluids as shown in Section 7.1.4.2.2., and the 3 alternatives have the same closure objectives (AWQSs) so the aquifer loading are considered the same for the three alternatives. .

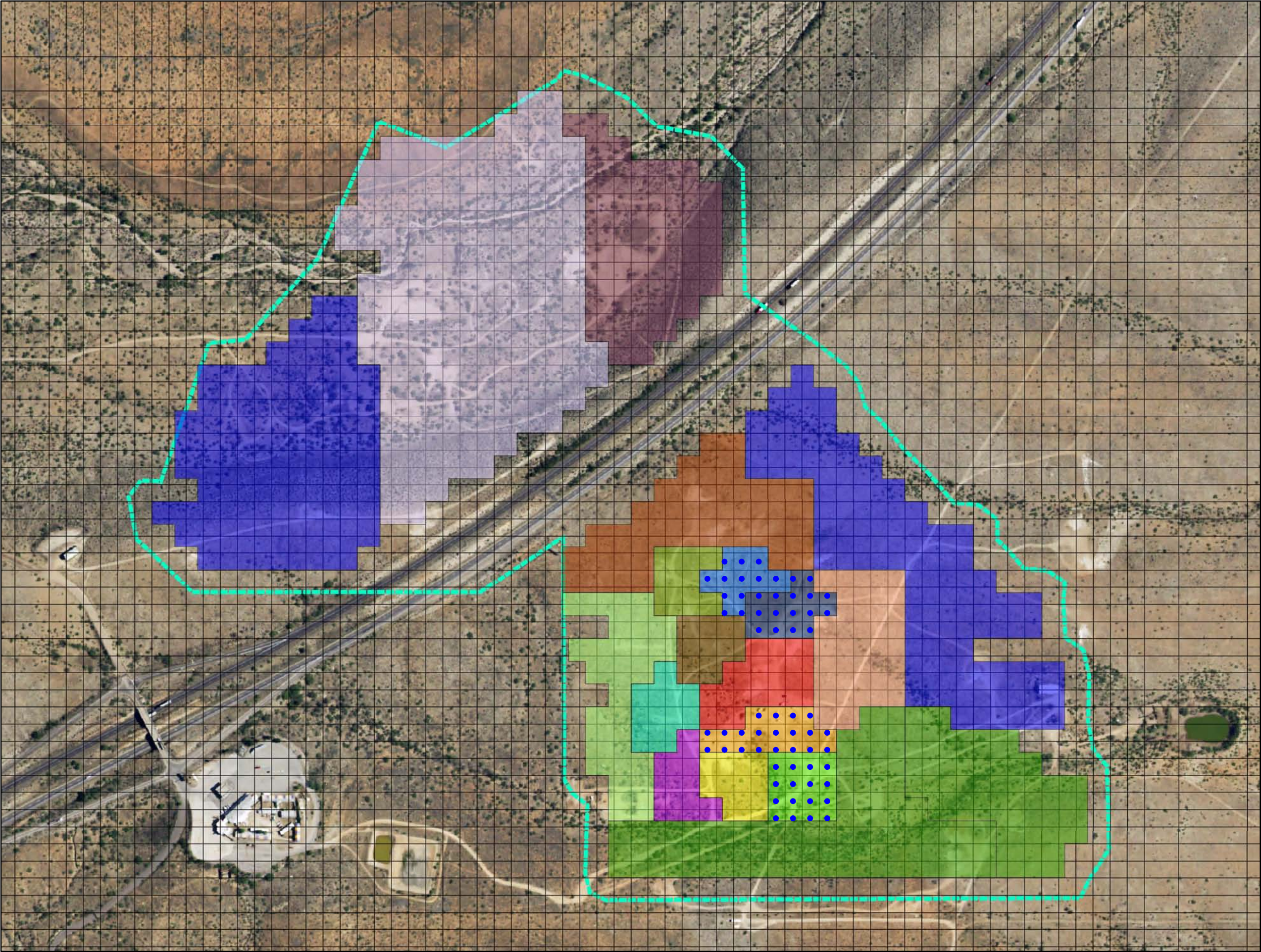
7.4.4 Summary

A table summarizing the alternatives is presented below.

	Alternative 1 Reference BADCT	Alternative 2	Alternative 3
	Hydraulic Control Wells around wellfield. Equal injection/recovery rates.	Extraction exceeds recovery by 3%. No hydraulic control wells around wellfield.	Equal injection/recovery rates in mining blocks, hydraulic control wells around each block of 3%.
Degree of Aquifer Loading	All alternatives inject same amount of lixiviant and propose to achieve AWQSs.		
Practicable and Economically Achievable?	Highest --least drawdown allows for most efficient copper recovery	Lowest --Loss of mineral resource due to ore dewatering	Same as Alternative 2. In addition, difficulties related to moving hydraulic control wells as mining progresses
Demonstratable	Yes, through monitoring at hydraulic control wells, intermediate monitor wells, and observation wells outside of hydraulic control wells	Yes, through injection/recovery rates.	Yes, through injection/recovery rates

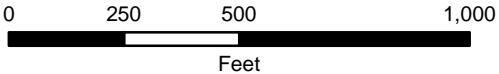
Water Resource conservation	Most conservative	Less Conservative	Same as Alternative 2
Technical Advantages	Efficient to implement; fixed hydraulic control well locations makes monitoring and demonstration of containment much easier	No need for separate hydraulic control system and water handling	Close control of mining block solutions
Technical disadvantages	Distance from mining block to HC system can be large. Intermediate monitoring locations can overcome this disadvantage. Not as simple to operate as alternative 2 with a fixed ratio of injection to recovery	Additional treatment and disposal capacity required.	Same as Alternative 2. Also, logistical complexity could increase the risk of inadvertent release of mining solutions

Based on all of these considerations, Excelsior proposes to implement the Reference Alternative.



Explanation

- | | |
|-------------------|-----------|
| • Wells Simulated | Year 9 |
| □ Model Grid | Year 10 |
| Year 1 | Year 11 |
| Year 2 | Year 12 |
| Year 3 | Year 13 |
| Year 4 | Year 14 |
| Year 5 | Year 15 |
| Year 6 | Year 16 |
| Year 7 | Year 17 |
| Year 8 | Wellfield |

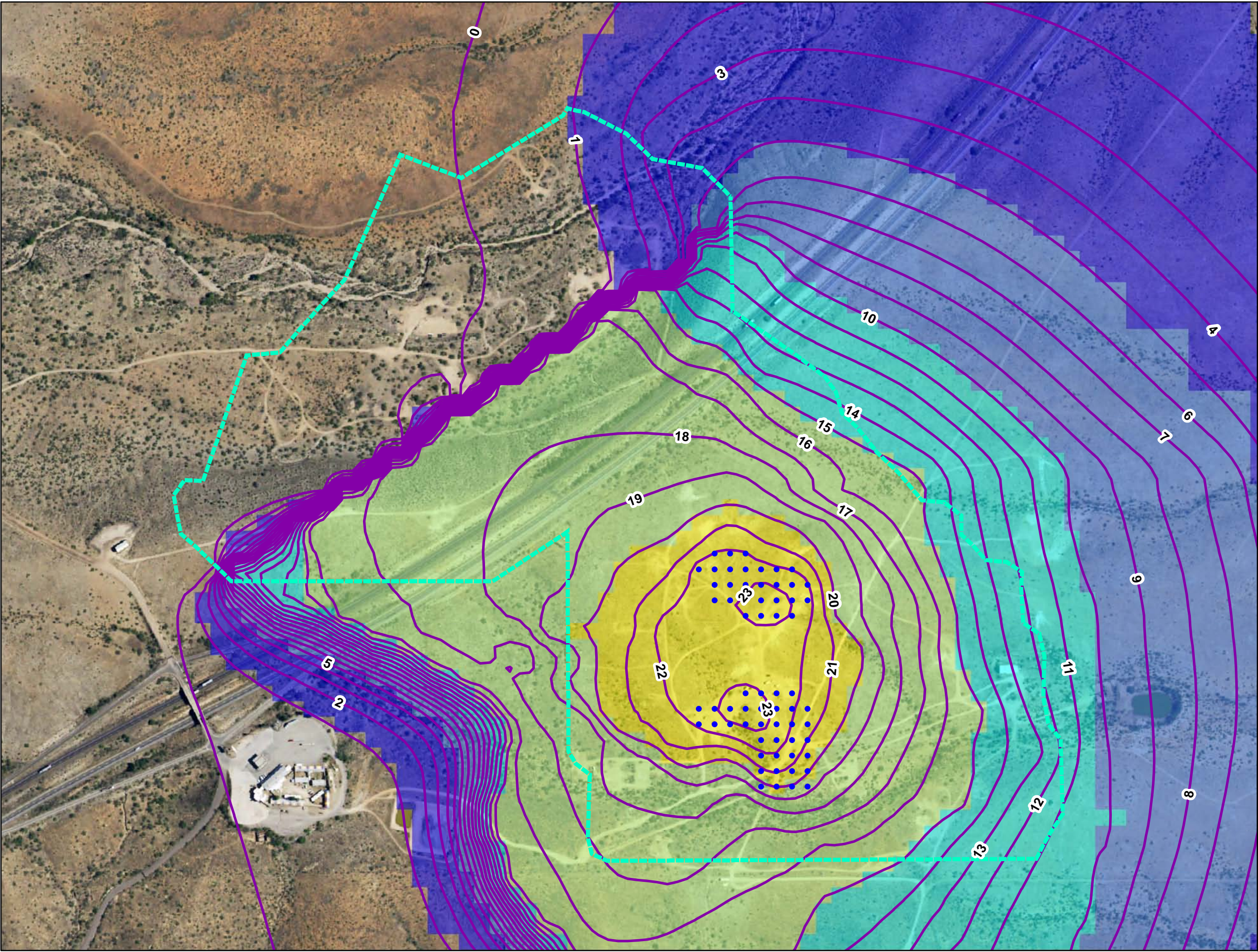


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FIGURE 16-1
Proposed New Block
Sequence and Net Overpumping
Wells for Mining Year 5



Explanation

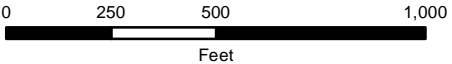
- Wells Simulated
- Drawdown Contours

Drawdown after 5 Years - Layer 4 (feet)

- 1.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00
- 15.01 - 20.00
- 20.01 - 30.00
- 30.01 - 50.00
- 50.01 - 100.00

Wellfield

NOTE: Aggregate pumping rate exceeds injection rate by 3% for this simulation.



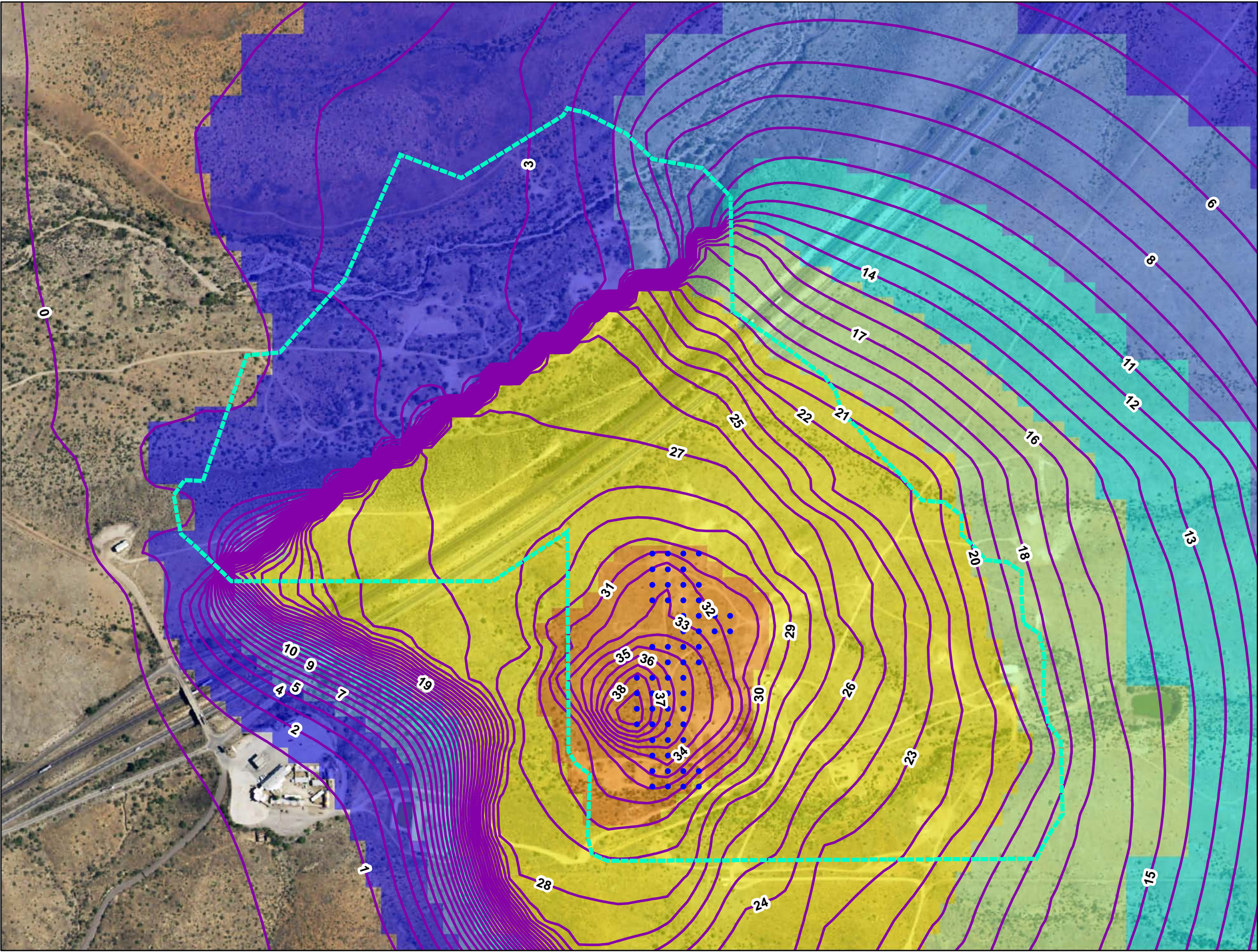
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FIGURE 16-2
Alternative 2 BADCT Demonstration
Drawdown in Layer 4
for Mining Year 5



Explanation

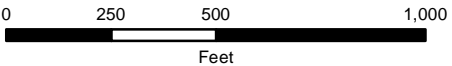
- Wells Simulated
- Drawdown Contours

Drawdown after 10 Years
- Layer 4
(feet)

- 1.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00
- 15.01 - 20.00
- 20.01 - 30.00
- 30.01 - 50.00
- 50.01 - 100.00

Wellfield

NOTE: Aggregate pumping rate exceeds injection rate by 3% for this simulation.



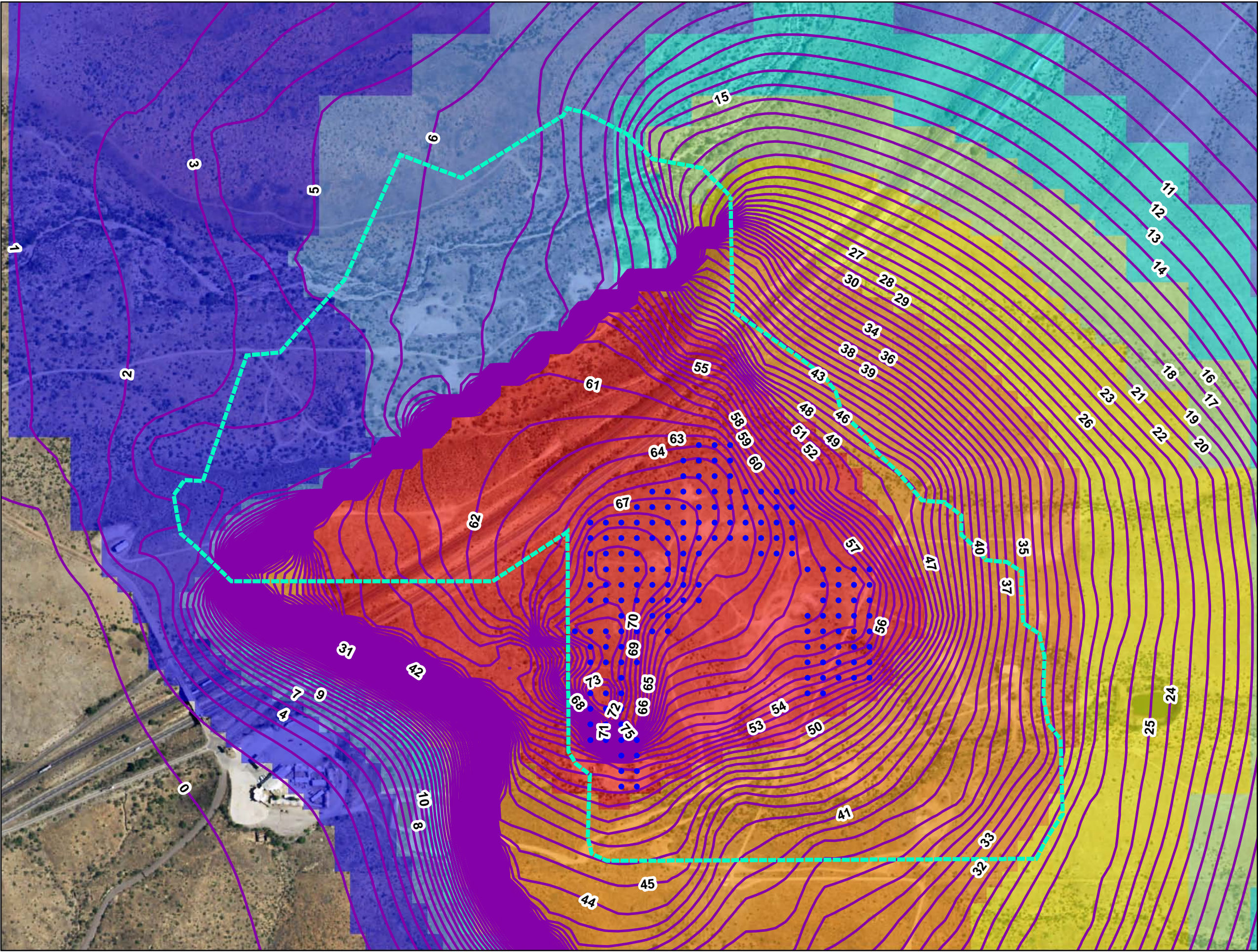
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FIGURE 16-3
Alternative 2 BADCT Demonstration
Drawdown in Layer 4
for Mining Year 10



Explanation

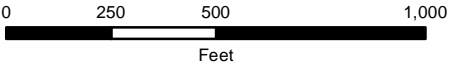
- Wells Simulated
- Drawdown Contours

Drawdown after 10 Years
- Layer 4

- (feet)
- 1.01 - 5.00
 - 5.01 - 10.00
 - 10.01 - 15.00
 - 15.01 - 20.00
 - 20.01 - 30.00
 - 30.01 - 50.00
 - 50.01 - 100.00

- Wellfield

NOTE: Aggregate pumping rate exceeds injection rate by 3% for this simulation.



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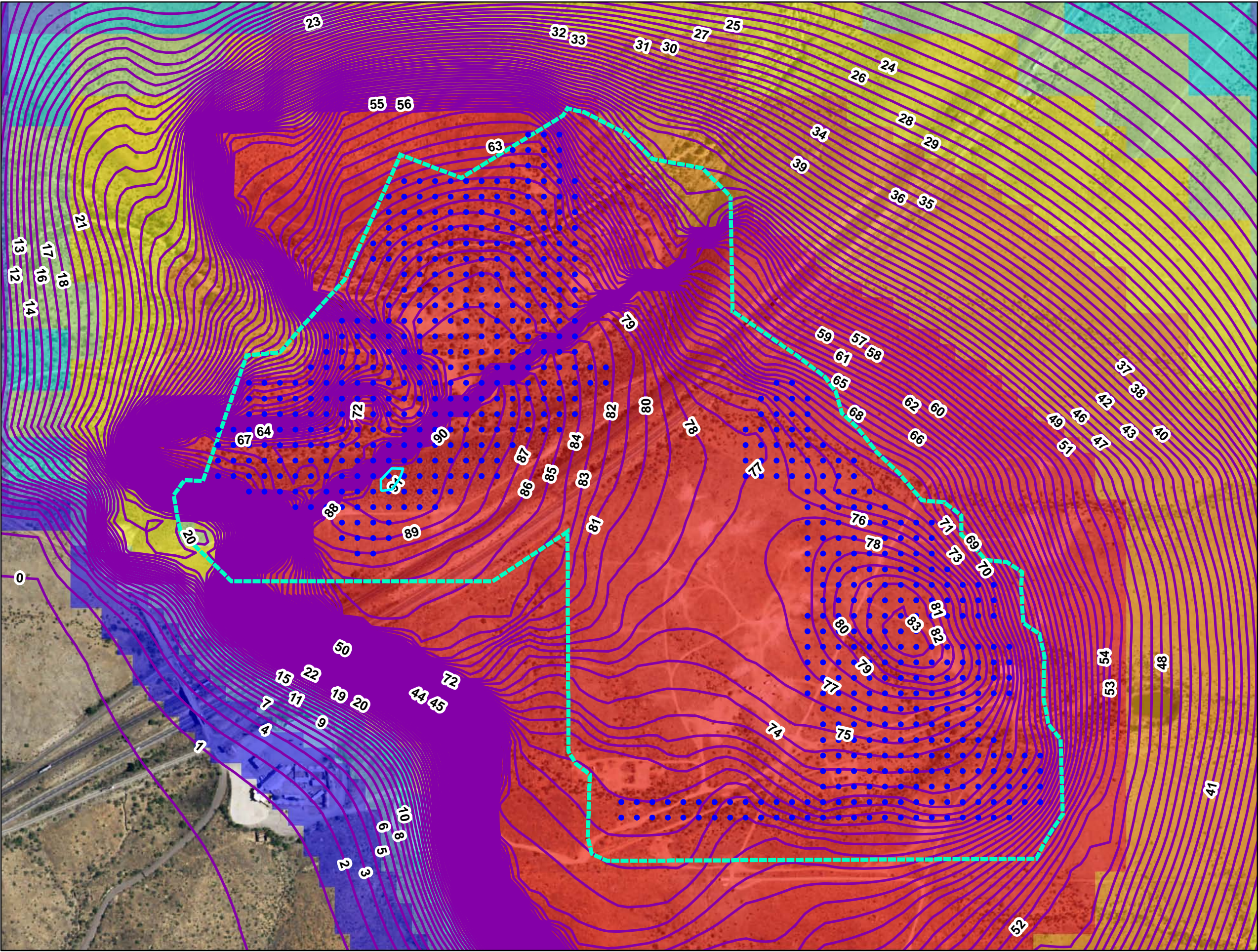
Date 9/1/16

File ID 373002



CLEAR
CREEK
ASSOCIATES

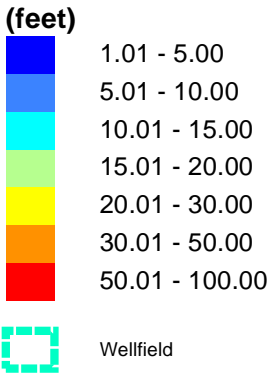
FIGURE 16-4
Alternative 2 BADCT Demonstration
Drawdown in Layer 4
for Mining Year 13



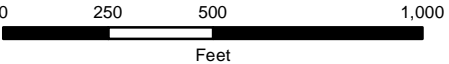
Explanation

- Wells Simulated
- Drawdown Contours

Drawdown after 16 Years
- Layer 4



NOTE: Aggregate pumping rate exceeds injection rate by 3% for this simulation.

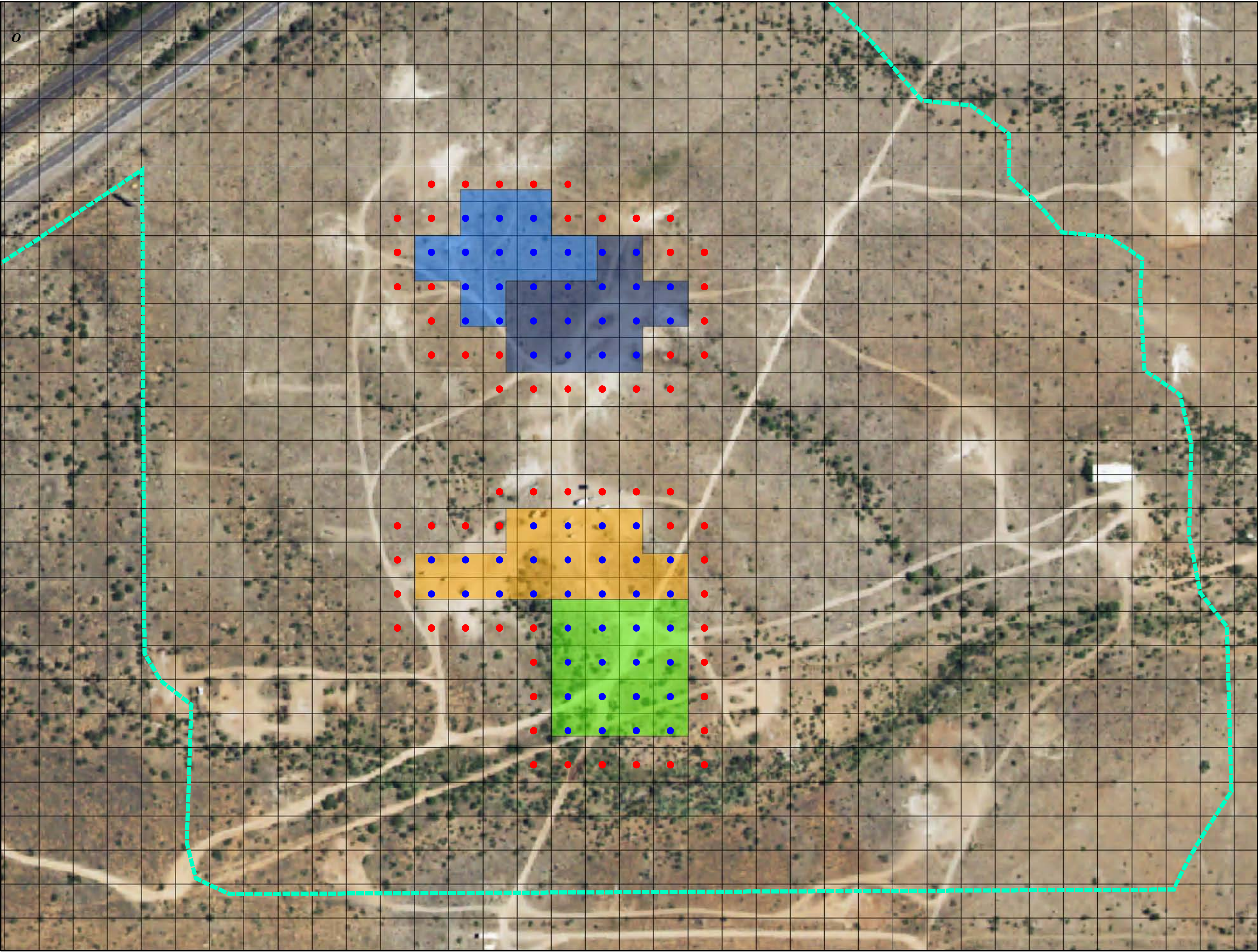


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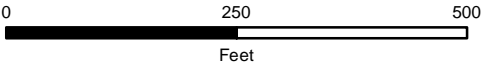


FIGURE 16-5
Alternative 2 BADCT Demonstration
Drawdown in Layer 4
for Mining Year 16



Explanation

- Particle starting points after 5
- Wells Simulated in Year 5
- Model Grid
- Year 2
- Year 3
- Year 4
- Year 5
- Wellfield



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FIGURE 16-6
Particle Starting Locations
for Mining Year 5

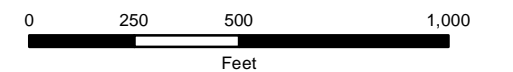
Explanation

23-Year Simulation -
3% Overpumping -
Particle Tracks

Model Layer

- 3
- 4
- 5
- 6

Wellfield

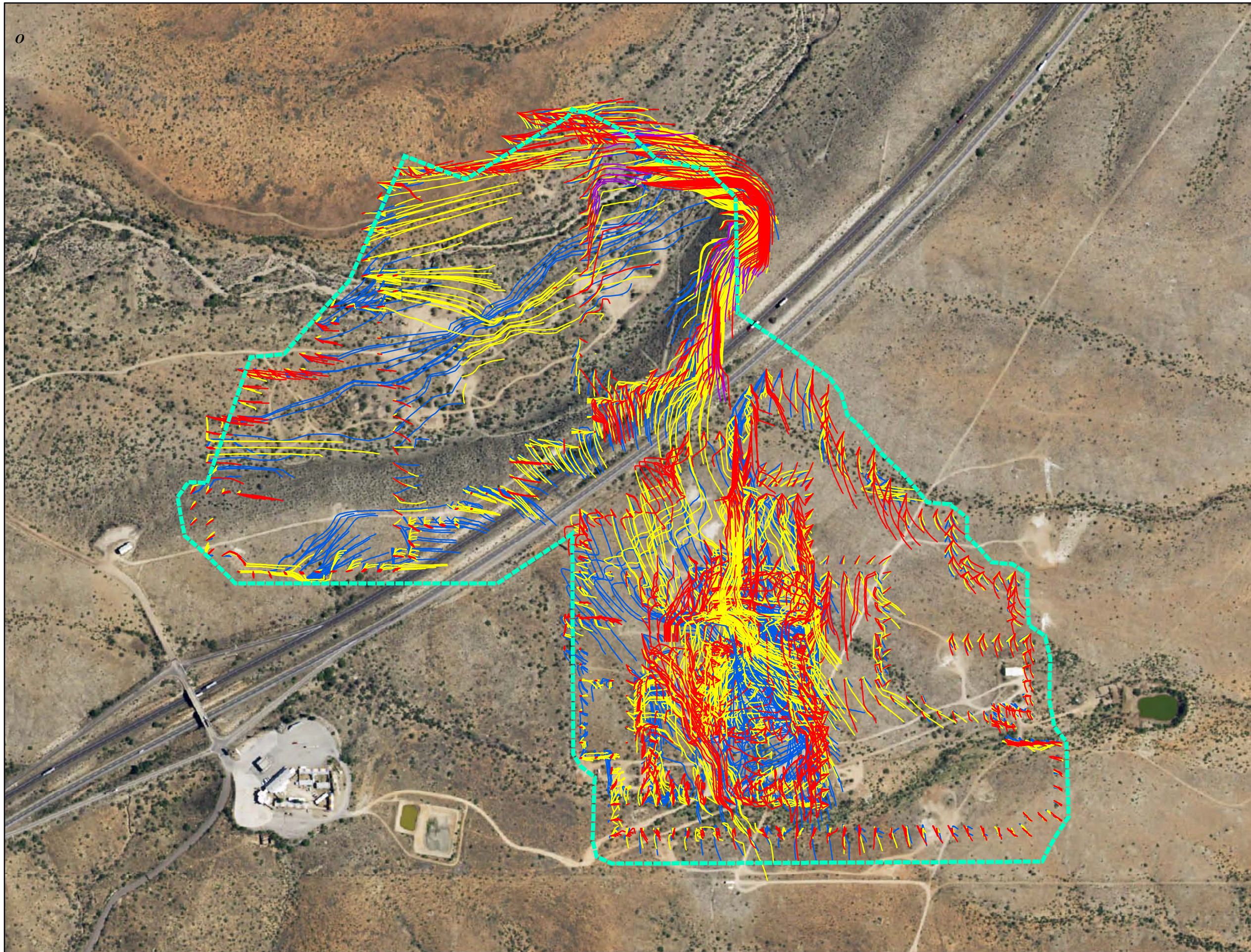


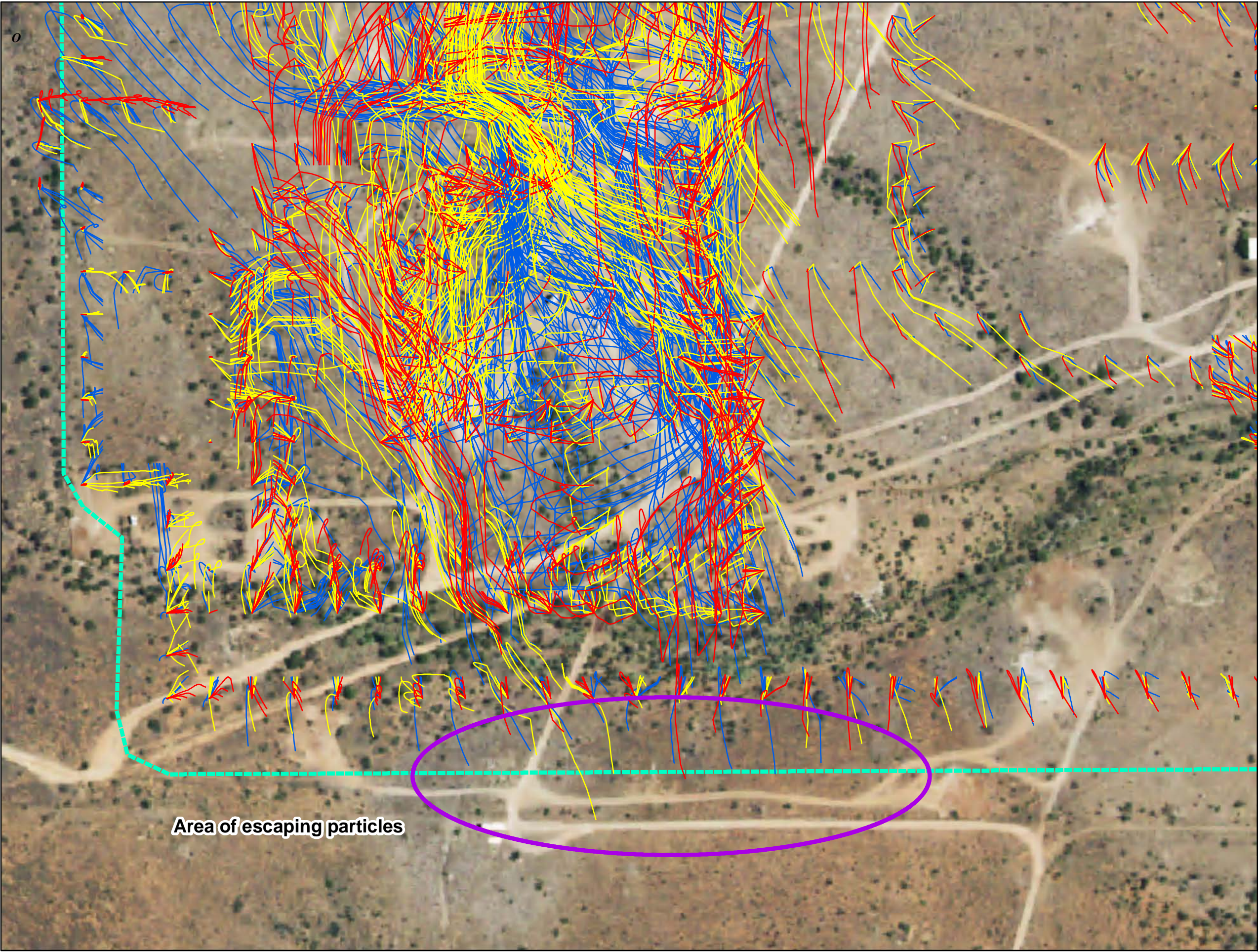
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FIGURE 16-7
Alternative 2 BADCT Demonstration
Particle Tracks - 3% Overpumping
23-Year Mining Period





Explanation

Particle Tracks for 23-Year Simulation

Model Layer

- 3
- 4
- 5
- 6

Wellfield

NOTE: Aggregate pumping rate exceeds injection rate by 3% for this simulation.

0 50 100 200 300 Feet

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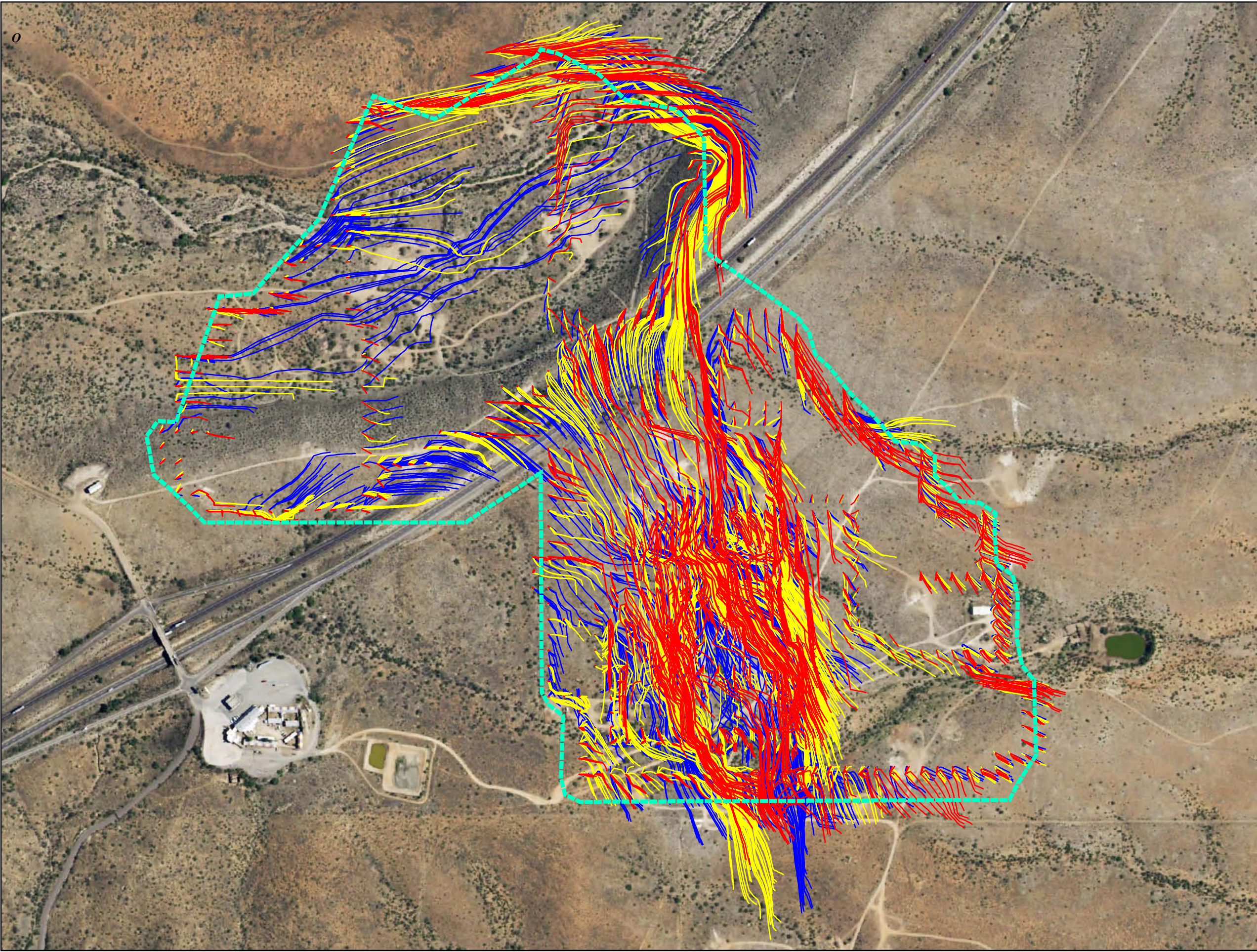
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FIGURE 16-8
Alternative 2 BADCT Demonstration
Uncaptured Particles after
23-Year Mining Period

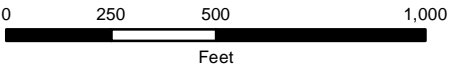


Explanation

Particle Tracks for 1%
Overpumping
Layer

- 3
- 4
- 5

Wellfield

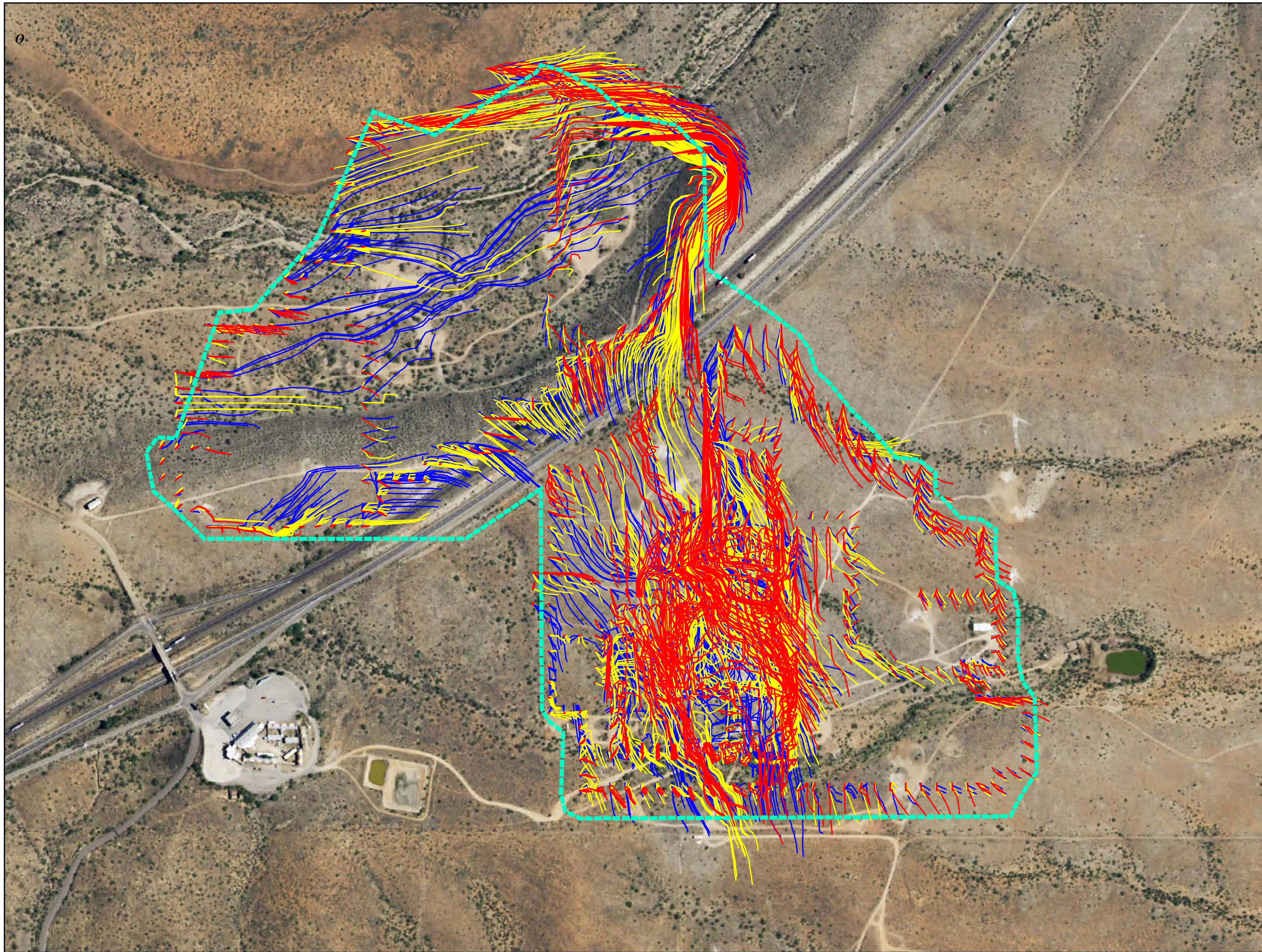


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FIGURE 16-9
Alternative 2 BADCT Demonstration
Simulation of 1% Overpumping
23-Year Mining Period

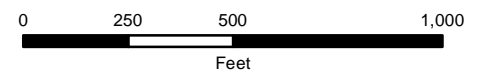


Explanation

Particle Tracks for 2%
Overpumping
Layer

- 3
- 4
- 5

Wellfield



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FIGURE 16-10
Alternative 2 BADCT Demonstration
Simulation of 2% Overpumping
23-Year Mining Period

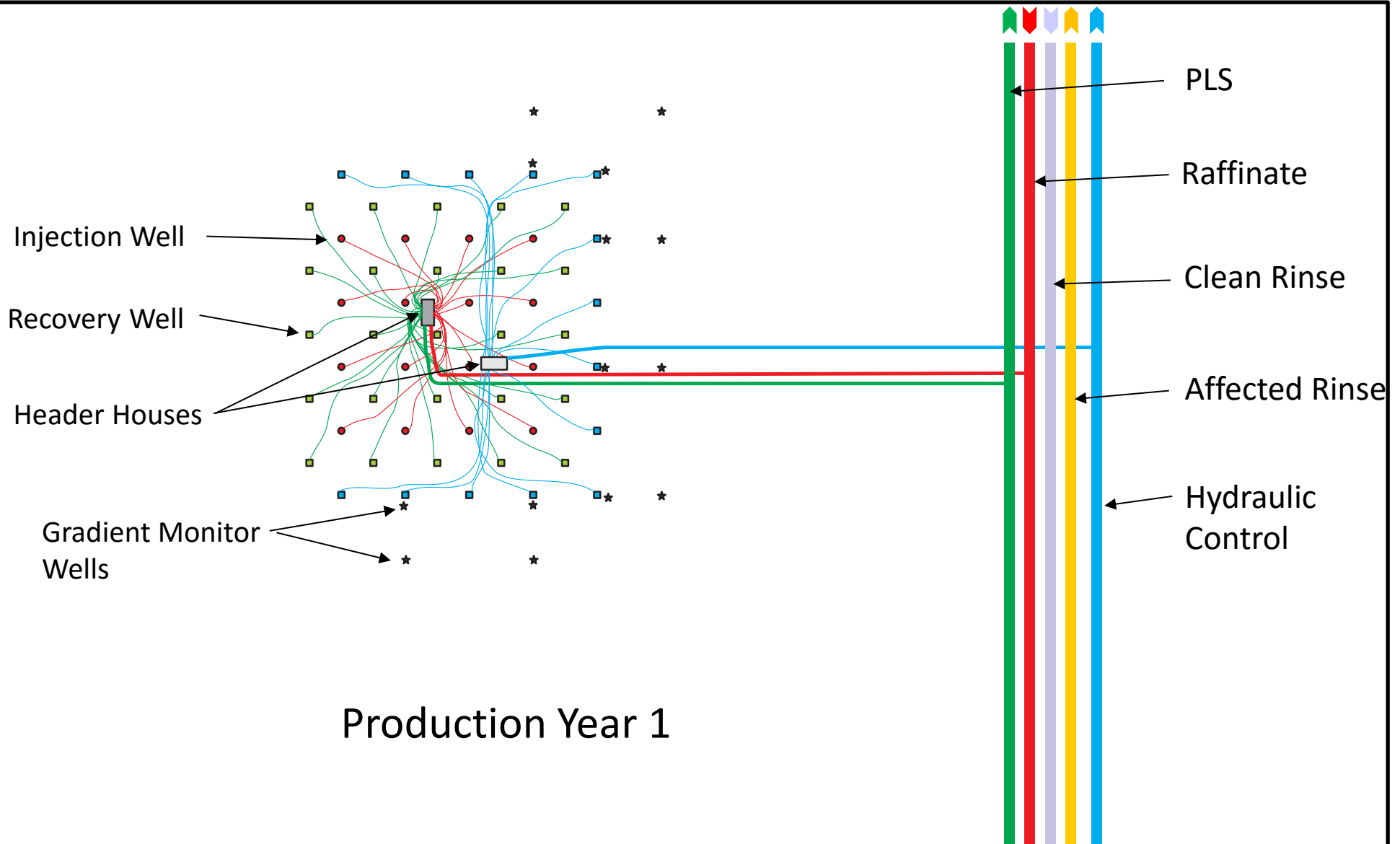
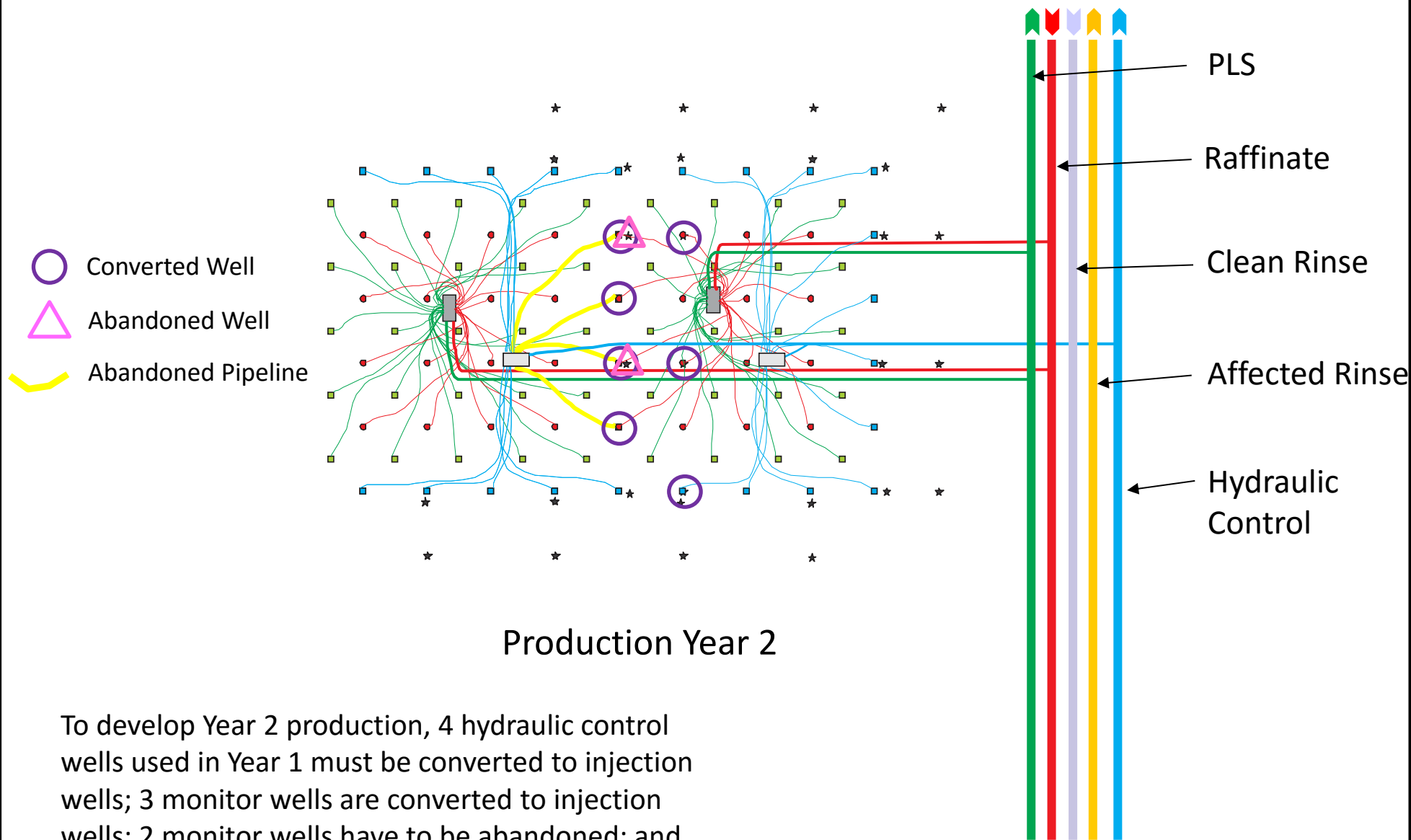


Figure 16-11
Alternative 3 Layout Schematic
Production Year 1
Response to ADEQ Comments
September 1, 2016



Production Year 2

To develop Year 2 production, 4 hydraulic control wells used in Year 1 must be converted to injection wells; 3 monitor wells are converted to injection wells; 2 monitor wells have to be abandoned; and piping to the converted hydraulic control wells has to be abandoned. This increases the chance of an inadvertent release or spill of solutions.

Figure 16-12
Alternative 3 Layout Schematic
Production Year 2
Response to ADEQ Comments
September 1, 2016

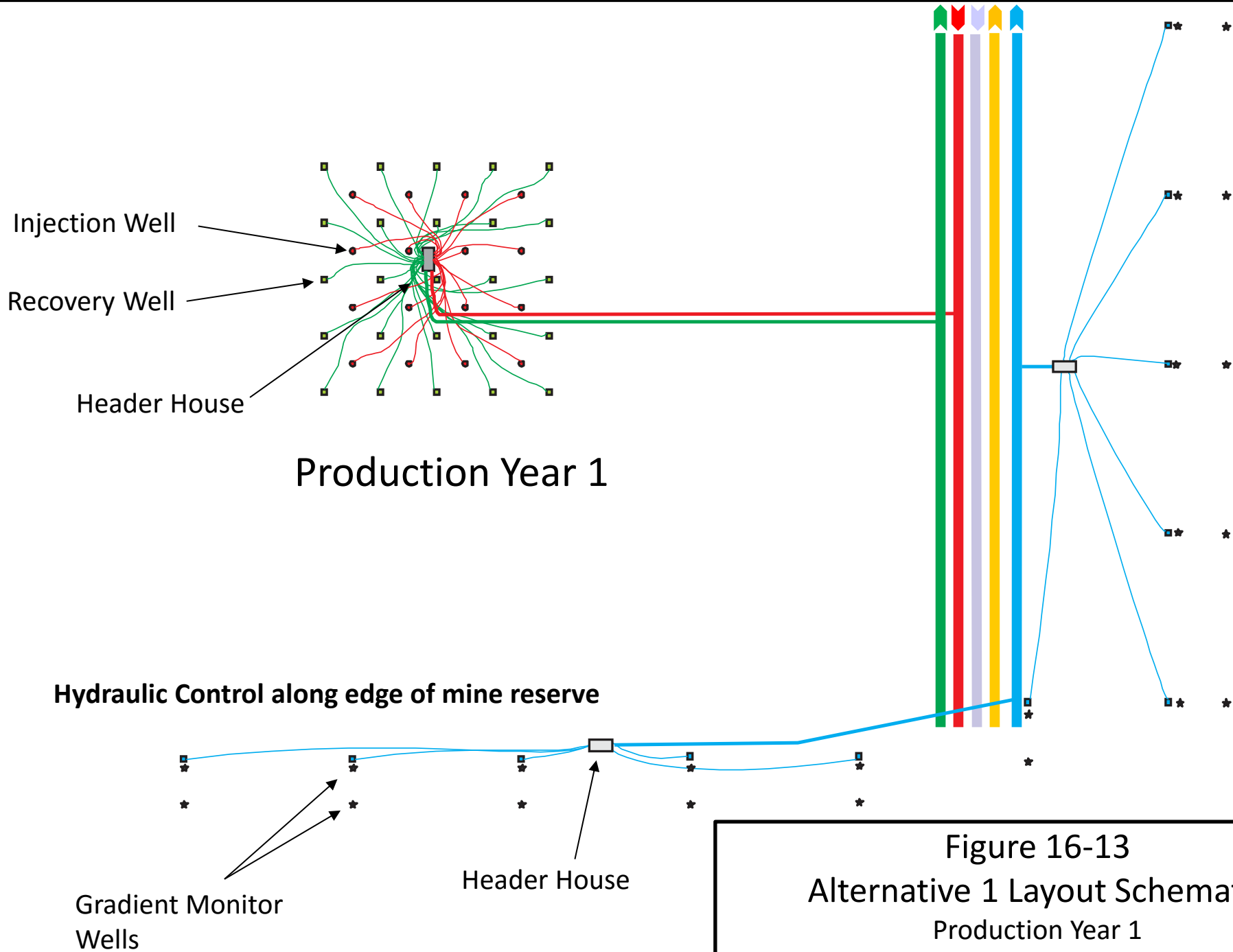
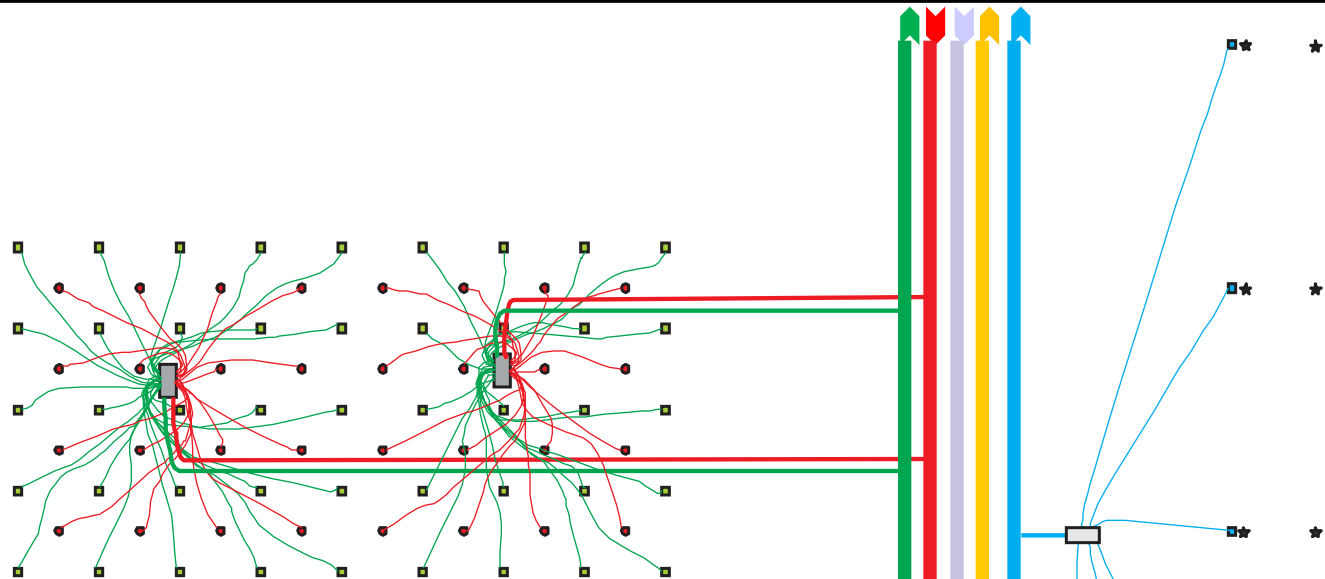


Figure 16-13
Alternative 1 Layout Schematic
Production Year 1
Response to ADEQ Comments
September 1, 2016



Production Year 2

No wells or pipelines need to be converted or abandoned reducing the chance of an accidental spill

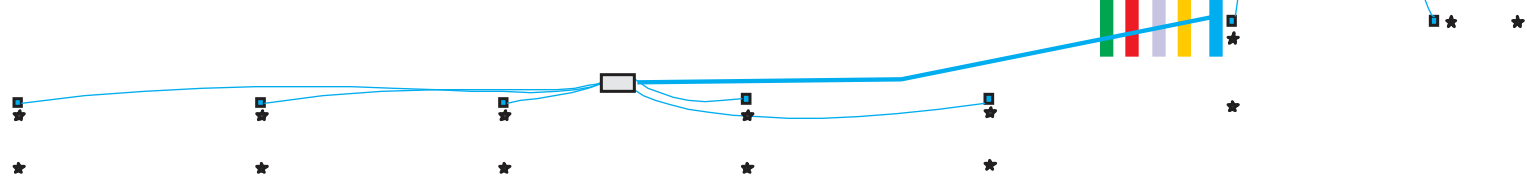
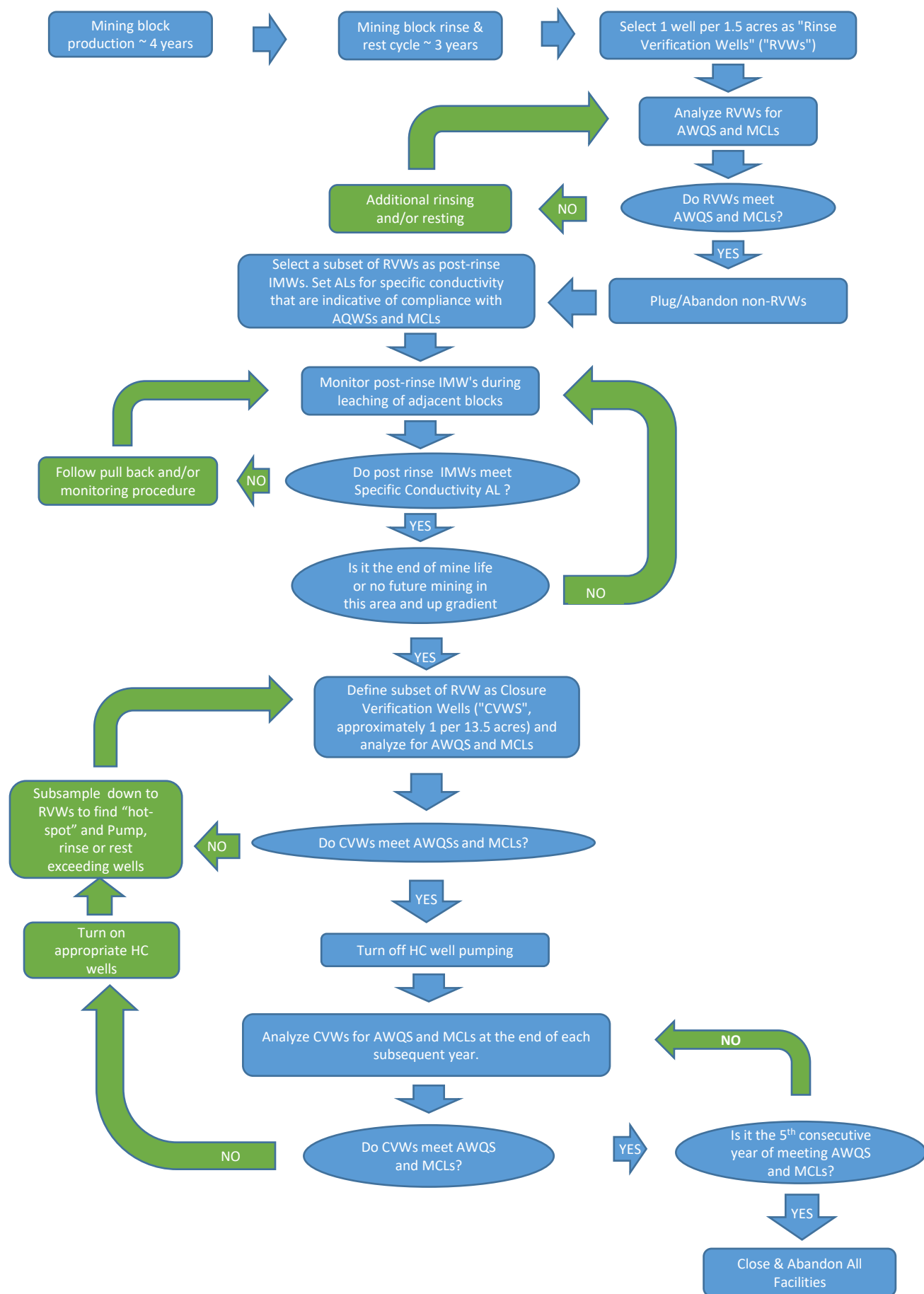
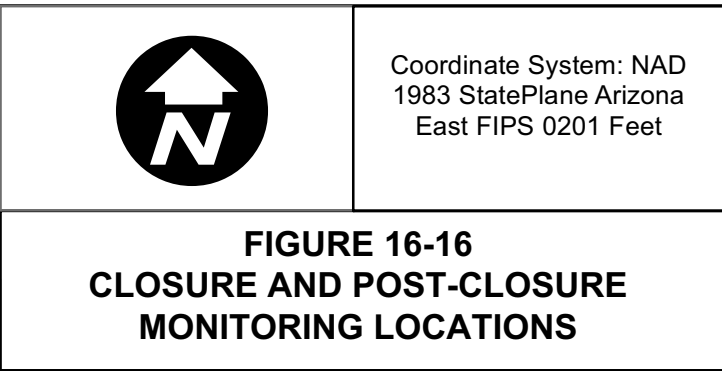
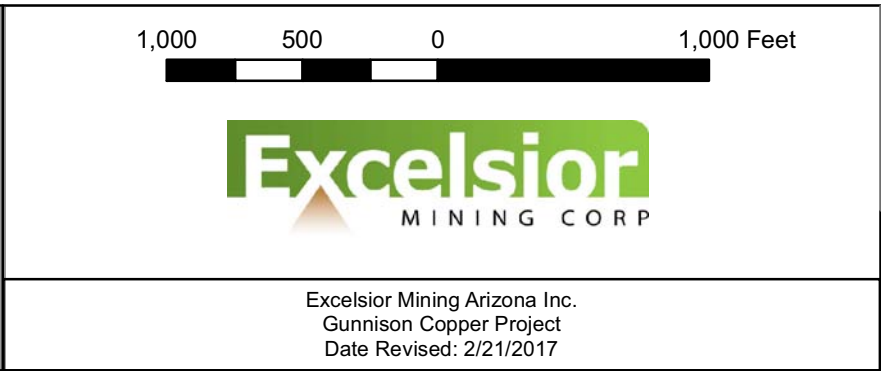
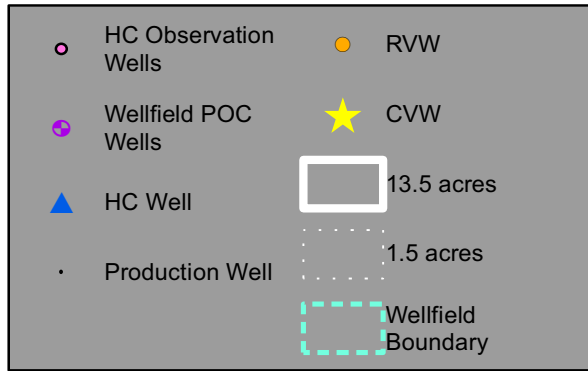
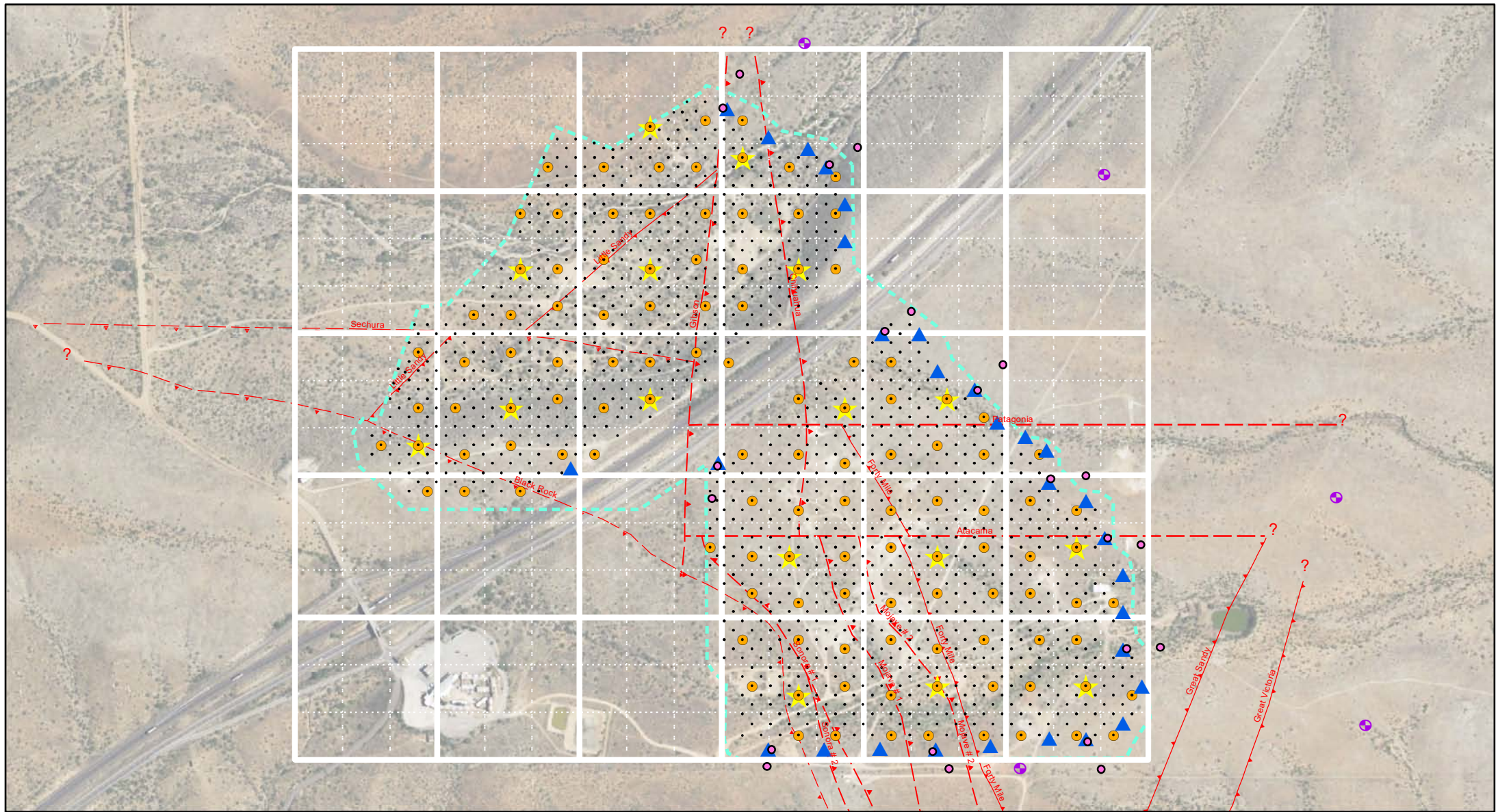


Figure 16-14
Alternative 1 Layout Schematic
Production Year 2
Response to ADEQ Comments
September 1, 2016

FIGURE 16-15: Closure Strategy Decision Tree





CRAI Comment

17. *A.A.C. R18-9-A202(A)(5)(a) – Section 7.1.4.2.2 indicates that injection rates will depend on several factors including the rate at which recovery wells can be pumped. Also, this section indicates “Compliance with a specific net volume or net rate of extraction in excess of injection is not proposed as a permit condition”. ADEQ disagrees, and believes that the permit should include alert levels and requirements to assure the extraction rate exceeds the injection rate so that hydraulic control and the cone of depression barrier are maintained.*

Provide permit conditions and alert levels to demonstrate maintenance of the cone of depression including the following:

- a. What are the criteria for selecting pumping or injection rates, and number of injection or recovery wells in a given area?*

ADEQ Evaluation

The response to RAI 17a is **not** adequate.

Excelsior proposes to maintain approximately balanced injection and recovery rates within the mining block to prevent significant drawdown. A proposed permit condition is that the 30-day rolling average of total volume of injected fluids will not exceed the 30-day rolling average of total volume of recovered fluids (production plus hydraulic control pumping).

Additionally, if the 30-day rolling average of total volume of injected fluids will not exceed the 30-day rolling average of production plus hydraulic control pumping, the contingency plan would be implemented. Based upon the BADCT discussion above in RAI 16 Alternative 1, a, Excelsior should include the following potential ALs for flow: total injection in the mine block(s), total recovery in the mine block(s) and total extraction at the hydraulic control wells.

The section also includes establishing a demonstrable gradient at the well field boundary establishing BADCT. Excelsior also indicates that if an outward hydraulic gradient is measured for one week or more, an inward gradient would be re-established. Excelsior must describe why one week of not having demonstrated capture is an appropriate time to allow the system to continue operating.

EXCELSIOR RESPONSE:

As with any mine, the grade and quantity of the ore will direct the facility’s operations. If copper is not recovered at the target concentrations, the number of wells and the injection and recovery rates will be adjusted accordingly. The principal criteria for selection of injection and recovery rates will be the copper grade observed at the SX/EW facility. The copper grade will dictate adjustments to flow rates to assure operational stability. Total injection will not exceed the ADEQ approved limit for each mining stage. Excelsior proposes to maintain approximately balanced injection and recovery rates within the mining block to prevent significant drawdown in the mining block thereby preserving as much of the mineral resource for mining as possible.

Initially, Excelsior proposes to operate the wellfield such that:

- hydraulic control pumping will be equal to 1% of injection pumping
- pumping and injection volumes will be collected daily and re-balanced on a 48-hour basis so that the 1% net extraction is maintained.
- an inward hydraulic gradient will be maintained as measured in observation wells located near the hydraulic control wells (Figure A-7).

After the first two months of operational data are available, they will be evaluated to determine appropriate permit limits regarding hydraulic gradients and net extraction rates. Excelsior will submit a report of the evaluation that determines whether a 30-day rolling average is as protective as the 48-hour flow volume re-balancing.

In addition, Excelsior proposed a permit condition (Section 9.4.2 in the APP Application) that an inward hydraulic gradient must be maintained outside of the hydraulic control well system during operation of each phase of the project. At selected hydraulic containment wells, observation well pairs will be installed to provide measurements of the inward hydraulic gradient. Excelsior anticipates that each HC well will have a unique relationship with its associated observation well pair. For instance, at some locations a small pumping rate will have a large impact on the hydraulic gradient while at other locations, higher pumping rates may have a small impact on hydraulic gradients. Therefore, the determination of pumping rate for each HC well should be determined empirically from testing. The ultimate ratio of withdrawal to injection will therefore be a function of testing and observation of aquifer response. The groundwater modeling of the proposed HC system indicates the overall ratio of withdrawal to injection needed for containment would range from <1 percent in year 1 to 3.2 percent in year 10. In order to minimize drawdown in the ore body, minimize the impact on the groundwater resource, and maintain full control of injected solutions, Excelsior will use field testing data to maintain a fluid flow balance that best protects the environment and document the inward gradient in reports submitted to ADEQ as noted below.

Regarding a specific value for the minimum inward hydraulic gradient to be maintained around the active portions of the ISR wellfield, Excelsior proposes to calculate a minimum gradient for each well pair based on their distance from each other and from testing and observation during the first two months of pumping at the associated hydraulic control well. Barometric pressure and earth tide differences are significant relative to potentially small head differences at observation wells; therefore, it will be important to remove barometric and earth tide responses from water level data collected with pressure transducers. At this time, we believe a minimum gradient of 0.01 ft/ft should be sufficient and measureable. Excelsior does not intend to use a pumping well to calculate hydraulic gradient, as well inefficiencies can exaggerate gradients. This methodology is conservative and defensible, while acknowledging the complex aquifer characteristics that have been identified and modeled.

The AL for each observation well pair will be a head difference established based on empirical data collected during testing of the hydraulic control well as described above. Excelsior has proposed (in Section 9.4.2.1 of the APP application) that six daily measurements (spaced 4 hours

apart) will be used to calculate daily average water levels. The AL will be triggered if the difference of the daily average head difference between two observation wells shows an outward gradient or an inward gradient is less than the AL for a period of more than one week. A one-week period is justifiable because the travel velocity of an excursion will be slow (the average particle velocity is 0.08 ft/day) and because it is anticipated that there will be small variations in measured hydraulic gradients caused by instrument error or short duration weather events. Per the proposed contingency plan (Section 10.2.2.1), when this occurs, Excelsior will initiate the following actions within 24 hours of becoming aware of an AL trigger:

- Evaluate the pumping rate in the nearest hydraulic control well(s)
- Adjust pumping rates to restore hydraulic control, as indicated by the observation well pairs.
- If a sufficient pumping rate cannot be achieved and maintained to restore hydraulic control, perform any operation, repair, and/or maintenance actions required to achieve the necessary pumping rate.
- Adjust pumping rates such that wellfield injection volumes do not exceed wellfield extraction volumes (including hydraulic control) according to a 30-day rolling average.

In support of the above method for maintaining hydraulic control, Excelsior will prepare groundwater contour maps, for inclusion in annual APP monitoring reports, to document hydraulic containment of the wellfield. Water levels from intermediate monitoring wells, observation wells, and POC wells will be used to construct the map. In addition, specific conductivity data will be used to evaluate containment. The data will be used to refine the numeric groundwater flow model as it is periodically updated.

CRAI Comment

b. Proposed alert levels for injection and recovery rates.

ADEQ Evaluation

The response to RAI 17b is **not** adequate.

Excelsior proposes to establish AL for each observation well pair to maintain an inward gradient, and if an outward hydraulic gradient is measured continuously for more than one week, the inward gradient will be re-established by one or more measures discussed in the application.

As stated above in ADEQ Evaluation for RAI 17a, Excelsior must provide a rationale as to why ALs should not be included in the permit.

EXCELSIOR RESPONSE:

Operation of the wellfield consists of two separate elements: (1) injection and recovery within the active mining blocks, and (2) hydraulic control at the perimeter of the wellfield. As long as hydraulic capture (inward gradients) is maintained at the wellfield boundary, the changes in the injection/recovery rates will not result in excursions from the wellfield. Excelsior has proposed overall net extraction during the life of mine, which will result in drawdown in the wellfield. But the net extraction will take place at the hydraulic control wells.

Based on this method of operation, no alert level is proposed for injection and recovery rates, except for the aforementioned proposed permit condition in Section 9.4.1 of the APP application (the 30-day rolling average of total volume injected fluids will not exceed the 30-day rolling average of recovered fluids [production plus hydraulic control pumping]).

The volume of injection and recovery will be limited by the SX-EW throughput. Injection rates and volumes will depend on a number of factors including:

1. The number of active injection wells (either in production, rinsing, or conditioning),
2. The rate at which the injection zone can accept lixiviant,
3. The rate at which recovery wells can be pumped.

Injection will include conditioning, leaching and rinsing operations. Recovery rates are limited by the SX-EW plant capacity. According to Excelsior's production schedule, the number of active Class III injection wells is anticipated to range from fewer than 20 in Year 1 to approximately 450 in Year 17. Therefore, over the life of the project, there will be considerable variation in the injection volumes. The following table provides the following for each Stage: Average/Maximum Pumping rates for each stage, hydraulic control pumping (per year) and net withdrawal per year. Please note that the net withdrawal is the same as the hydraulic control pumping because injection will approximately equal extraction.

Stage 1				Stage 2				Stage 3				Post Production Rinsing			
Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control (gpm)	Net Pumping (gpm)	Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control	Net Pumping	Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/Conditioning)	Hydraulic Control	Net Pumping	Year	Average/Maximum Injection/Recovery GPM (Leaching/Rinsing/conditioning)	Hydraulic Control	Net Pumping
1	5,300 / 6,000	15	15	11	15,800/ 17000	125	125	14	25,600 / 28,000	155	155	21	850/ 1,400	191	191
2		45	45	12		125	125	15		160	160	22		191	191
3		45	45	13		125	125	16		125	125	23		123	123
4		50	50					17		175	175				
5		68	68					18		175	175				
6		82	82					19		191	191				
7		125	125					20		191	191				
8		125	125							191	191				
9		125	125							191	191				
10		125	125												
	AVERAGE		80				125				173				168

The actual field conditions encountered during operation will determine the pumping and injection rates. Compliance with a specific net volume or net rate of extraction in excess of injection is not proposed as a permit condition, as it is expected to vary depending on the block(s) being mined and rinsed.

ADEQ COMMENT:

c. Proposed net differential (e.g. percentage difference) that achieves greater extraction than injection.

EXCELSIOR RESPONSE:

As explained above, the hydraulic control system of wells around the perimeter of the mining operation is a primary component of BADCT for the wellfield operations. The hydraulic control system is designed to operate independently of the mining operations and has several advantages over greater recovery rates than injection rates in the mining block. These include:

- Minimize drawdown in the mining block thereby conserving the mineral resource (an element of practicability).
- Minimize the amount of water pumped thereby conserving the groundwater resource.
- Avoid pumping groundwater mixed with mining solutions, thereby allowing other uses for the water and avoiding disposal of a waste product.
- Providing a fixed line of control that will not have to be migrated with each mining block. Operation of the hydraulic control wells will be closely monitored over time allowing adjustment of operations based on changes in observed gradients outside the control system.

The appropriate BADCT requirement is maintenance of an inward hydraulic gradient at the line of hydraulic control surrounding the wellfield. As long as this is achieved, the actual pumping and injection rates and the difference between them, is irrelevant. Excelsior understands the importance to the mining operation of controlling solutions in the subsurface. Excelsior will be monitoring injection/recovery and hydraulic control pumping rates. Therefore, as an additional permit condition, Excelsior proposed (in Section 9.4.1 of the APP Application) that “Total injection, production, and hydraulic control volumes will be monitored and recorded daily. These inflow/outflow measurements will be recorded at approximately the same time each day. The proposed permit condition is that the 30-day rolling average of total volume of injected fluids will not exceed the 30-day rolling average of total volume of recovered fluids (production plus hydraulic control pumping). If the 30-day moving average of the injection volume exceeds the 30-day moving average of production plus hydraulic control pumping, the contingency plan requirements will be implemented.”

ADEQ COMMENT:

d. Maximum injection pressure.

EXCELSIOR RESPONSE:

The maximum injection pressure is proposed to be 0.75 psi/ft based on fracture gradient testing conducted in 29 packer intervals in six formations as discussed in Section 7.1.4.2.3 of the original APP Application.

e. An alert level for the inward hydraulic gradient. The alert level should be a differential between the water level observed in the intermediate monitoring wells (higher) as compared to the recovery wells (lower).

ADEQ Evaluation

The response to RAI 17e is **not** adequate.

As stated in ADEQ Evaluation for RAI 16, Alternative 1, a, ADEQ requests that additional lines of evidence be utilized to demonstrate capture including groundwater contour maps showing capture at the POC wells and to establish what is going on within the mine block.

Excelsior provided the same discussion as above to Part a. regarding losing hydraulic control for a week. Please see ADEQ Evaluation for RAI 17.a, pertaining to hydraulic control loss.

EXCELSIOR RESPONSE:

Excelsior agrees to inward hydraulic gradient alert levels, as described in the response to 17a. However, the gradients will be measured at the perimeter of the wellfield, not within or near the mining blocks. As discussed above, this has several advantages for monitoring and field testing hydraulic control. The gradient will be monitored primarily through the use of pressure transducers that are calibrated approximately once per month with measurements made using an electric sounder. In the event that an alert level (loss of inward hydraulic gradient at the hydraulic

control wells) appears to have been reached for one week or more at one or more of the observation well pairs based on transducer data (6 readings per day are proposed, at 4-hour increments), water level measurements will be made using an electric sounder. If sounder measurements confirm that an alert level has been reached, one or more of the measures described under comment 17.a., above, will be implemented to re-establish the inward hydraulic gradient.

In support of the above method for maintaining hydraulic control, Excelsior will prepare groundwater contour maps, for inclusion in annual APP monitoring reports, to document hydraulic containment of the wellfield. Water levels from intermediate monitoring wells, observation wells, and POC wells will be used to construct the map. In addition, specific conductivity data will be used to evaluate containment. The data will be used to refine the numeric groundwater flow model as it is periodically updated.

f. Propose monitoring of the cone of depression and how it will be verified through direct measurement at the PMA boundary.

ADEQ Evaluation

The response to RAI 17f is **not** adequate.

“The cone of depression created by the hydraulic control wells will be monitored by measuring water levels with transducers at a frequency of once-per-day (or greater) at the observation well pairs. The observation well pairs on the east side of the wellfield are located inside the PMA but outside the wellfield boundary. Groundwater quality will be monitored at the PMA boundary in the proposed POC wells.”

As stated above in ADEQ Evaluation for RAI 17e, ADEQ requests additional lines of evidence ensuring capture is demonstrated.

EXCELSIOR RESPONSE:

The cone of depression created by the hydraulic control wells will be monitored by measuring water levels with transducers at the observation well pairs. The observation well pairs on the east side of the wellfield are located inside the PMA but outside the wellfield boundary. Groundwater quality will be monitored at the PMA boundary in the proposed POC wells.

Measuring inward gradient at the eastern PMA boundary is not feasible because the PMA boundary is based on the maximum extent of the inward gradient, as predicted by the groundwater flow model. In the early years of mining, the PMA boundary will be outside of maximum extent of inward gradient.

Excelsior will prepare groundwater contour maps, for inclusion in annual APP monitoring reports, to document hydraulic containment of the wellfield. Water levels from intermediate monitoring wells, observation wells, and POC wells will be used to construct the map. In addition, specific conductivity data will be used to evaluate containment. The data will be used to refine the numeric groundwater flow model as it is periodically updated. As mining progresses, it

will be possible to see expansion of the capture zone from the hydraulic control wells toward the POC wells.

CRAI COMMENT 18:

18. The application does not include a map clearly identifying the location of the various wells at each stage of the project. Also, Section 7.1.4.2.1 indicates the strategy for controlling solutions is to install hydraulic control wells that will generate overlapping cones of depression around the perimeter of the wellfield. Assumptions in the model include “over the duration of the Project, the total rate of pumping from the ISR wells and hydraulic control wells will be adjusted and maintained to exceed the total rate of lexiviant injection”.

This section also states that the location of hydraulic control wells are approximate and the locations will be determined by site-specific conditions and the progression of in-situ mining activities. Also, Section 9.4.2.1 indicates hydraulic control will be monitored by measuring fluid levels in observation well pairs installed in bed rock. ADEQ cannot issue a permit based on a conceptual plan of maintaining hydraulic control.

EXCELSIOR RESPONSE:

The plan for maintaining hydraulic control is not conceptual. The planned locations of the hydraulic control wells are shown on Figure 18-1. As discussed in the response to Question 8, the groundwater model was constructed at an appropriate scale to simulate the hydraulic control wells and identify specific locations for them. It is reasonable and prudent to allow for some flexibility in the locations based on site conditions such as topography, access, or other physical obstacles at the surface. In addition, the geology encountered when drilling the borehole must be taken into consideration. For example, if no significant fractures are encountered during drilling, it would not be appropriate to construct and operate a well at that location, because it would not be effective to attempt to pump groundwater from solid rock. It would be more effective to abandon the borehole and drill a replacement well in the immediate vicinity.

The proposed hydraulic control monitoring program is also not conceptual. Please see the response to ADEQ’s comment 17.

ADEQ COMMENT: *Per A.A.C. R18-9-A202(A)(1), (2), and (4), please, provide a site plan and a topographic map showing boundaries for each stage (Stages 1, 2, and 3) of the project. Indicate the location of the injection, recovery, intermediate monitoring, observation, hydraulic control, and point of compliance (POC) wells, and the pollutant management area (PMA) for each stage of the 5-spot well pattern on the requested map. The anticipated location and numbers of wells that will be installed during Stage 1 will be required, since a number of factors including but not limited to the PMA and DIA boundaries, and closure costs associated with Stage 1 are dependent on this information. Please note that the as-built location of the injection, recovery, intermediate monitoring, observation, and hydraulic control wells will be required prior to initiation of injection as an amendment to the permit.*

ADEQ Evaluation

The response to RAI 18 (part 2) is **not** adequate.

The response included center points for each mine block in Figure 18-2. In addition, Excelsior provided a table, Table 18-1, that indicates how many injection/recovery, existing monitoring, hydraulic control, POC and observation wells. Based upon the table, it is indicated that 2 Observation wells will be installed in year 1 with three hydraulic control wells. However Excelsior's response to RAI 16 Alternative 1 (page 7-6 of revised BADCT demonstration), indicated that two observation wells would be placed at each hydraulic control well. Based upon the table, there seems to be a contradiction, please clarify.

EXCELSIOR RESPONSE:

Figure 18-2 displays the locations of the injection and recovery wells proposed for this project, and also shows the location of the hydraulic control wells. Figure 18-3 illustrates the location of the Point of Compliance wells, the hydraulic gradient monitoring wells and the hydraulic control wells. Table 18-1 lists the wells, based on their year of installation, proposed for this project, by stage. It also includes already existing monitor wells at the Site.

Observation well pairs at adjacent hydraulic control wells can be used to show inward gradients during testing of the hydraulic control wells. At this time, it is anticipated that 30 hydraulic control wells are needed to maintain inward gradients and hydraulic capture. Excelsior plans to install observation well pairs at 11 of the hydraulic control wells.

Table 18-1 Well Installations by Year for Gunnison Copper Project

Stage	Year	Injection and Recovery Wells	Existing Monitor Wells	Hydraulic Control Wells	Point of Compliance Wells	Observation Wells
1	1	38	30	3	3	2
1	2	20	0	2	0	2
1	3	20	0	0	0	0
1	4	17	0	1	0	2
1	5	21	0	3	0	0
1	6	16	0	2	0	2
1	7	18	0	8	0	6
1	8	20	0	0	0	0
1	9	14	0	0	0	0
1	10	16	0	0	0	0
2	-	203	0	0	7	0
3	-	1004	0	11	0	8
Total		1407	30	30	10	22

Table 18-2 lists each well by type and location, including easting and northing.

ADEQ COMMENT: *Please note that the as-built location of the injection, recovery, intermediate monitoring, observation, and hydraulic control wells will be required prior to initiation of injection as an amendment to the permit.*

EXCELSIOR RESPONSE:

As-built locations can be provided for all wells. However, it is not appropriate to address this through a permit amendment. A permit amendment will result in significant costs and delays. Excelsior proposes to address this requirement as a compliance schedule item. Please note that this permit is for a mining operation. By their very nature, mining operations require flexibility in operations as varying geologic conditions are encountered during the progression of the mine's development. An amendment should be required only if the operations or the points of compliance change significantly from what was specified in the permit application. Table 18-2 lists all proposed wells for the project, including easting and northing.

ADEQ COMMENT: *a. The applicant must provide approximate center position locations for each injection/recovery well cluster per A.A.C. R18-9-A202(A)(2).*

EXCELSIOR RESPONSE:

Please see Figure 18-2. Table 18-2 lists all proposed well locations for the project.

The response to RAI 18a is **not** adequate.

Excelsior referred to Figure 18-2 and Table 18-2 which provides a list of all wells including northing and easting. However, ADEQ requests that the center point for each mine block be referenced in latitude and longitude.

EXCELSIOR RESPONSE:

Center Points for Stage 1 mining blocks are provided below:

Name	NAD83X	NAD83Y	Latitude	Longitude
Y1	738285	393727	32.0823847°	-110.0430457°
Y2	738328	393491	32.0817358°	-110.0429077°
Y3	738397	394027	32.083209°	-110.0426829°
Y4	738189	394175	32.0836165°	-110.0433540°
Y5	738448	393245	32.0810592°	-110.0425211°
Y6	738156	393248	32.0810683°	-110.0434639°
Y7	737923	393263	32.0811103°	-110.0442162°
Y8	737846	393578	32.0819765°	-110.0444637°
Y9	738046	393852	32.0827291°	-110.0438169°
Y10	737916	394137	32.0835129°	-110.0442356°

ADEQ COMMENT:

- b. *Provide the rationale for the location of the PMA in relation to the wells, to demonstrate that the PMA is drawn at the limit of the area where pollutants will be placed, including the barrier designed to contain pollutants in the facility pursuant to A.R.S. 49-244.1. Please note that the PMA should be drawn at a location where the cone of depression will be monitored as a permit condition and hydraulic control must be demonstrated on a continuous basis.*

ADEQ Evaluation

The response to RAI 18b is **not** adequate.

To the first part of the comment, Excelsior indicated that the hydraulic control well network creates a cone of depression which forms the barrier. Figures 60, 61, and 62 in Appendix I of the APP Application define the areas of capture.

To the second part of the comment, Excelsior indicated that hydraulic control will be demonstrated on a continuous basis at the observation wells; however, the PMA is located at the break in hydraulic gradient (i.e. the edge of the hydraulic barrier). Excelsior must indicate that hydraulic control will be demonstrated at the POC wells.

EXCELSIOR RESPONSE:

ARS 49-244.1 states that the Pollutant Management Area (PMA) includes a “barrier designed to contain pollutants in the facility.” The hydraulic control well network proposed for this project creates a cone of depression which forms the barrier. Figures 60, 61 and 62 in Appendix I of the APP Application define the areas of capture by the hydraulic control wells along the northern and eastern boundaries of the ISR wellfield.

ADEQ COMMENT (2nd part): *Please note that the PMA should be drawn at a location where the cone of depression will be monitored as a permit condition and hydraulic control must be demonstrated on a continuous basis.*

EXCELSIOR RESPONSE:

Hydraulic control will be demonstrated on a continuous basis at observation wells associated with the hydraulic control pumping wells. However, the proposed PMA is located at the break in the hydraulic gradient (i.e. the edge of the hydraulic barrier), as allowed by ARS 49-244.1.

The cone of depression created by the hydraulic control wells will be monitored by measuring water levels with transducers at the observation well pairs. The observation well pairs on the east side of the wellfield are located inside the PMA but outside the wellfield boundary. Groundwater quality will be monitored at the PMA boundary in the proposed POC wells.

Measuring inward gradient at the eastern PMA boundary is not feasible because the PMA boundary is based on the maximum extent of the inward gradient, as predicted by the groundwater flow model. In the early years of mining, the PMA boundary will be outside of maximum extent of inward gradient.

To provide additional lines of evidence for hydraulic control, Excelsior will prepare groundwater contour maps, for inclusion in annual APP monitoring reports, to document hydraulic containment of the wellfield. Water levels from intermediate monitoring wells, observation wells, and POC wells will be used to construct the map. In addition, specific conductivity data will be used to evaluate containment. The data will be used to refine the numeric groundwater flow model as it is periodically updated. As mining progresses, it will be possible to see expansion of the capture zone from the hydraulic control wells toward the POC wells. However, from a demonstration perspective, it is most feasible to show the inward gradients at observation well pairs.

CRAI Comment 20

20. A.A.C. R18-9-A202(A)(5)(a) – During Stage I, process solutions will be stored and managed at the Johnson Camp Mine (JCM) facility. Please provide a water balance that includes the volume of fluids that will be sent to the JCM facility from the project site to demonstrate that the ponds at JCM are adequately sized. Please provide a contingency plan to manage solutions at the Project Site, in the event the ponds at the JCM facility are unable to store additional fluids, or should the pipeline to JCM become inoperative. An estimate of volumes maintained in the pipeline to JCM should be provided.

ADEQ Evaluation

The response to RAI 20 is **not** adequate.

Excelsior indicated that a water balance for the Stage 1 operations was submitted with the Gunnison APP application, and included the JCM process solution ponds.

Excelsior submitted an amendment application for the Johnson Camp Mine (JCM) permit in which they have provided a water balance for the ponds located at the JCM facility.

Regarding managing solutions as a contingency measure during pipeline repairs, Excelsior proposed to installation of a single-lined pond called the Pipeline Drain Pond. Based on the largest anticipated pipe having an outside diameter of 24 inches, the proposed capacity of the pond including design storm volume and two feet freeboard is 1.05 acre-feet. Drawing contained a plan sectional views of the impoundment. However, anchor trench details were missing. Please provide anchor trench details. Also, please clarify what the value of 3.65 used in the calculation of design storm volume represents.

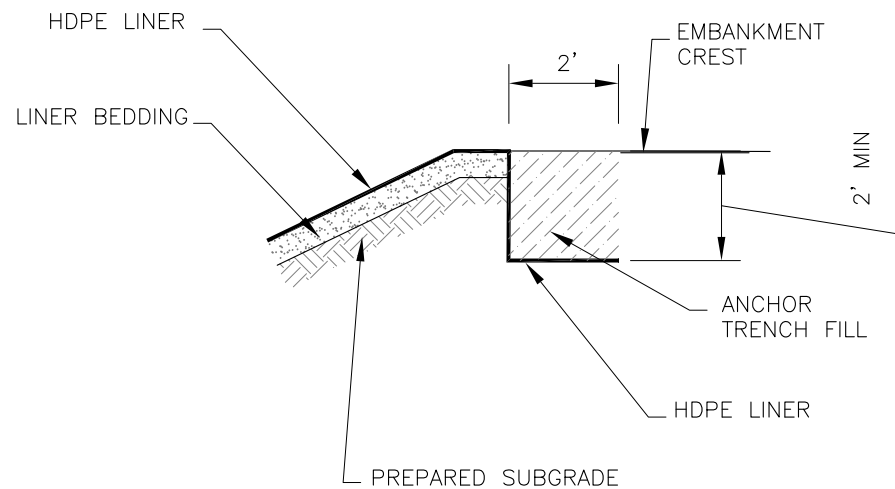
RESPONSE

An anchor trench detail for the Pipeline Drain Pond is attached.

The value used in the calculation of the design storm volume should have been 3.89 inches (the 100-year, 24-hour storm) and not 3.65 inches. The additional volume due to a 3.89- inch storm amounts to 162 cubic feet (cf). The table with updated volumes is presented below.

Table 2.1 Pipeline Drain Pond Volume Requirements

24" Diameter Pipe Volume (ft³)	Design Storm Volume (ft³)	Two (2) Feet Freeboard Volume (ft³)	Total Volume Required (ft³)	Total Volume Provided (ft³)
22,014 (164,600 Gal) 0.505 AF	2,626 (19,640 Gal) 0.06 AF	14,468 (7,234 ft ² x 2 feet) 0.332 AF	39,108 (0.898 AF)	45,742 (1.05 AF)



ANCHOR TRENCH DETAIL

NOT TO SCALE

PREPARED FOR: 	PREPARED BY: AXELROD INC. <small>PHOENIX, ARIZONA</small>	PROJECT: GUNNISON COPPER PROJECT	TITLE PIPELINE DRAIN POND ANCHOR TRENCH DETAIL	SCALE AS SHOWN	DATE: 2/6/17	REVISION
				FIGURE No. 1		

CRAI Comment

23. *A.A.C. R18-9-A202(A)(5)(a) – Section 3.4, Site Specific Geology, indicates there are 217 drill hole data points in the region, including 122 drill holes immediately in the resource area, and 95 drill holes within the project area. As per Section “3.4.5.3.1 Discharge Control - In-Situ Leaching With Deep Well Injection” of the BADCT manual, “Boreholes or wells, which may act as conduits for leachate to contaminate aquifers, should be plugged and abandoned in accordance with Arizona Department of Water Resources rule R12-15-816 and required UIC regulations (40 CFR Part 146)”. Please indicate the schedule and procedure to abandon the drill holes and any other boreholes and wells located within the project area or the immediate vicinity of the ISLR operations.*

This section also indicates there are several faults within the project area. Please provide an evaluation of the potential for activating a fault based on the proposed in-situ and recovery operations.

ADEQ Evaluation

The response to RAI 23 is **not** adequate.

Excelsior indicated that they plan to retain the NSH monitoring wells to serve as intermediate monitoring wells, and plug and abandon wells/coreholes within the wellfield that will not be used as intermediate observation wells prior to injection operations. Prior to injection operations these borings will be left open since they may be used as observation wells during aquifer testing. Please see ADEQ Evaluation for RAI 16, Alternative 1, c on when a well and/or core hole would be abandoned. The abandonment procedure described in Excelsior’s response to RAI 23 is adequate.

EXCELSIOR RESPONSE:

In response to this comment, Excelsior has revised Section 7.1.4.3 of the wellfield BADCT demonstration (revised version provided in response to comment 16) by adding the following text:

Prior to leaching in each mine block, Excelsior will plug and abandon pre-existing wells and. As mining blocks progress, any coreholes or boreholes in a new mining block that are not constructed to Class III requirements, will be abandoned before mining of that block begins. In these cases, plugging or abandonment of the boreholes will be conducted as described in below, using a method consistent with the “Standard Abandonment Method” in the ADWR Well Abandonment Handbook (2008).

CRAI Comment

29. *A.A.C. R18-9-A202(A)(5)(a) – Section 7.1.4.2.2 states “An inward hydraulic gradient will be maintained around the active portions of the ISR wellfield, as measured in observation wells located near the hydraulic control wells”. Also, Section 10.2.2 indicates “Loss of hydraulic control may occur if fluid levels in the observation wells do not show an inward hydraulic gradient towards the wellfield”.*

Please note that an inward hydraulic gradient towards the recovery wells shall be established and confirmed prior to the injection of acidified process solution into the injection wells and maintained at all times. Please provide a description of the automatic controls and alarms that will be used in the well field to ensure process upsets do not result in the loss of hydraulic control.

ADEQ Evaluation

The response to RAI 29, part 1 is **not** adequate.

Excelsior indicated “The quoted passage should not be construed to suggest that fluid levels in observation wells are in any way the cause of hydraulic control loss. The statement was intended to convey that fluid levels in the observation wells may indicate, but do not necessarily confirm that the hydraulic gradient toward the wellfield has been lost.” “As discussed in response to comment 28, depending on the location of active mining, it could take months or years for a particle to exit the wellfield in the event of hydraulic control loss.”

Excelsior does not propose to measure this gradient between injection and recovery wells because levels in pumping and injection wells do not accurately reflect levels in the aquifer. Instead, gradients will be measured at observation well pairs associated with the hydraulic control wells. The water level elevations in each pair will be compared to confirm that the inboard water level elevation is an established amount lower than that in the outboard well. Alarm conditions will notify the operators to implement corrective actions if the water level elevation difference approaches an established alarm level. The actual amount will be established in the field during operations, and this can be addressed as a compliance schedule item.

The evaluation of the amount of time that is needed for excursions of PLS to travel from mine well blocks to the hydraulic control wells is presented above in ADEQ Evaluation to RAI 8.a.ii. In addition, as stated above in ADEQ Evaluation to RAI 16, Alternative 1, a, ADEQ requests Excelsior use multiple lines of evidence, i.e., potentiometric contour map, for establishment of capture per A.A.C. R18-9-A202(5)(b).

EXCELSIOR RESPONSE:

In response to RAI 16, Excelsior included the following verbiage in Section 7.1.4.2.1 of the BADCT demonstration document:

To provide additional data demonstrating hydraulic control, Excelsior will prepare groundwater contour maps, for inclusion in annual APP monitoring reports, to document hydraulic containment of the wellfield around the active blocks. Water levels from intermediate monitoring wells and observation wells will be used to construct the map. Groundwater chemistry (specific conductivity, will also be evaluated as an indicator of hydraulic control. The data will be used to refine the numeric groundwater flow model as it is periodically updated.

PART 2

29. Please include a description of the mechanical controls and monitoring devices for the well field injection system(s). An explanation of the process, corrective action, and how these devices will regulate injection and recovery fluid flow should also be provided. The controls and monitoring devices should include:

Injection Well System:

- a. Pressure gauge.*
- b. Flow meter at the injection manifold for measuring flow rates in gallons per minute (gpm).*
- c. Totalizing flow meter for measuring cumulative flow (gallons) into the injection manifold.*
- d. Flow switch at each injection well for indicating flow.*
- e. Valve(s) at each injection well for controlling flow.*

Recovery and Hydraulic Control Wells:

- a. Continuous reading flow meter (gpm) at the recovery manifold.*
- b. Totalizing flow meter (gallons) at the recovery manifold.*
- c. Isolation valve(s) at each recovery well.*
- d. Flow switch at each recovery well.*
- e. Pressure transducer within all or selected recovery wells. Transducers were not noted on the well diagrams provided in Section 7.1.4.4 (Volume I) Figures 7-2 through 7-4.*

ADEQ Evaluation

The response to RAI 29, part 2 is **not** adequate.

Excelsior indicated that controls for the injection and recovery wells will be located in the Header House. With the exception of the pressure transducers for each production well, Excelsior will install the above mentioned controlled and monitoring devices. A transducer may be installed at the discretion of the operator in an individual well or group of wells as the operator considers necessary.

Per A.A.C. R18-9-A205(A) and R18-9-A206(A), Excelsior shall include transducers for all injection, recovery, hydraulic control, intermediate monitoring (NSH wells), and observation wells in order to monitor groundwater elevations to ensure the cone of depression is being maintained at the PMA boundary.

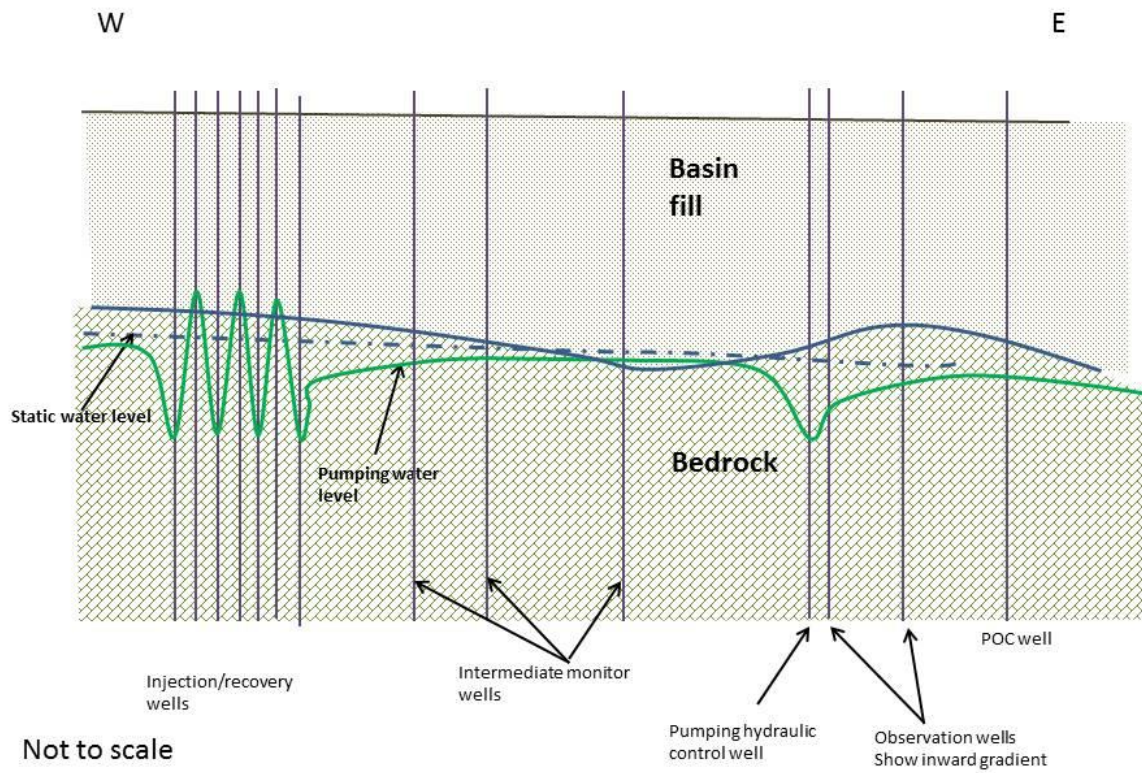
EXCELSIOR RESPONSE:

Excelsior agrees that transducers should be installed in intermediate monitoring wells and observation wells in order to monitor inward hydraulic gradients. However, monitoring of groundwater elevation data from hydraulic control wells and injection/recovery wells will not be helpful in evaluating hydraulic gradients.

As shown on the “Wellfield Concept” schematic drawing below, within active mining blocks, injection and recovery wells will cause significant fluctuations in water levels. Because water (lixiviant) levels in injection and recovery wells will be constantly changing they will not provide suitable data for evaluating hydraulic gradients, and it is unclear how the data from pressure transducers in these wells could be used for this purpose. The hydraulic control wells will provide containment of wellfield solutions. Because these wells are pumping wells with inherent inefficiencies, the water levels in the hydraulic control wells will not be an accurate indicator of the aquifer water levels¹. Therefore, Excelsior plans to monitor water levels at two observation wells instead. One of the observation wells will be very close to the hydraulic control well, and another will be located farther away. The head differences in these wells will establish whether the hydraulic control wells are being operated effectively.

¹ Excelsior will evaluate hydraulic control well efficiencies during aquifer testing. It may be feasible to use water levels in the hydraulic control wells to evaluate inward gradients. However, Excelsior intends to use the observation wells as the primary indicator of hydraulic gradients.

Wellfield Concept



CRAI Comment

36. A.A.C. R18-9-A202(A)(5)(a) - *Please provide the design for erosion control (rip-rap or diversion ditches, etc.) to protect the elevated portions of perimeter embankments. Please indicate the approximate height of the embankment in relation to the surrounding ground level for the cross-section view of all the ponds presented in Appendix K, Figures K-2 through K-8. In some cross-sections, there appears to be no embankment provided, please explain. Indicate arrows on the drawings to show where the surface flows are anticipated to enter the pond.*

In case of the Plant Runoff Pond, Section 7.5, Volume I, indicates that surface flows will be directed into the western end of the pond. Please indicate if the Plant Runoff Pond is designed to accept surface flow along the entire western edge. Indicate arrows on Drawing No. 350-CI-008 to show where the surface flows are anticipated to enter the pond. Also, Section R of the same drawing shows a relatively small embankment along the western edge. Please indicate the height of the embankment on the drawing.

ADEQ Evaluation

The response to RAI 36 is **not** adequate.

Rip rap along the toe of selected slopes were added to the revised drawings provided in response to Comment 38. Embankments higher than existing ground are not always necessary since pond edges along higher ground with small contributing watersheds have minor run-on potential. Run-on into ponds will be prevented by ditches, swales and berms.

Plant Runoff Pond design was revised (figure K-8 in response to Comment 38) to promote controlled inflow into the pond.

Excelsior included a document titled "Plant Site Drainage Analysis Summary" prepared by M3 Engineering dated August 29, 2016 on a CD. However, this document was not sealed by the engineer. Per A.R.S. § 32-101(B)(11), please re-submit the document prepared by M3 Engineering with the Arizona registered professional engineer's seal.

EXCELSIOR RESPONSE:

A stamped report is attached.

M3-PN160076
Drainage Analysis Summary
08-29-2016
Revision 2



GUNNISON COPPER

Plant Site Drainage Analysis Summary

Owner:

Excelsior Mining

Performed by:

Adam Edwards, PE
M3 Engineering



1 TYPE OF ANALYSIS

1.1 Hydrology:

A watershed peak flow analysis was performed for the drainage areas contributing to the Gunnison plant site and adjacent proposed process ponds. The 100-year, 24-hour storm (Q100) was selected as the design storm for the analysis but the 10-year, 24-hour storm (Q10) is also included in [Appendix C](#).

1.2 Hydraulics:

A culvert capacity analysis was completed using the Federal Highway Administration (FHWA) HY-8 program to determine the required culvert capacity during the design storm for the plant site.

A channel capacity analysis was completed using the FHWA Hydraulic Toolbox program to determine the required channel capacity during the design storm for the plant site and diversions around the process ponds. In certain areas, ponding is created by the placement of the process ponds and a HydroCAD model was used to determine the maximum water surface elevation (WSEL) expected during the design storm.

A HEC-RAS analysis was conducted to establish the water surface elevations in a natural watershed south of the plant site that impacted the proposed layout.

2 PURPOSE AND SCOPE OF ANALYSIS:

The Gunnison project site is located east of Interstate 10 and SE of the Johnson Camp mine site. The analysis completed was to evaluate the existing and proposed watersheds impacting the Gunnison site and surrounding proposed ponds and to determine the channel capacities needed to divert the runoff around the process ponds or to the storm water detention pond. Analytical methods were used to calculate the peak discharges, runoff volumes, and to determine the existing water surface elevations in the designed channels as well as the proposed sumps upstream of the process ponds. Peak flows were analyzed for each watershed contributing to surface water flows upstream of the plant site or proposed ponds using the HydroCAD program which uses both Soil Conservation Service (SCS) TR-20 methods (SCS, 1982) and TR-55 methods (USDA, 1986). An SCS 24-hour Type II storm was selected for simulation due to the projects location. All watersheds were delineated as depicted on the watershed map located in [Appendix A](#).

KEY ASSUMPTIONS:

- Soil class C was chosen based on USDA Web Survey results for the area.
- Several SCS Curve Numbers (CN) were used to describe the existing and developed watersheds. They are as follows:
 - A CN of 85 was used for existing surfaces as it corresponds to a Poor Desert Shrub surface, HSG C.
 - A CN of 91 was used for developed surfaces as it corresponds to a Newly Graded surface, HSG C.
 - A CN of 98 was used for impervious surfaces such as rock outcroppings located in existing surfaces or lined ponds in developed surfaces.
- Minimum time of concentration set to 5 minutes for all watersheds.
- Minimum impervious area set to 10% of the watershed area.
- A Manning's number of 0.035 was used for the dumped riprap swales or channels.
- A Manning's number of 0.030 was used for natural channels that have winding paths with grass understory.
- A Manning's number of 0.025 was used for proposed earthen channels or swales.

PROCEDURES AND METHODS USED:

- Peak Discharges:
 - Calculated by the SCS methods using HydroCAD.
 - Time of concentration was calculated using the SCS Lag time method.
 - The length of longest watercourse, L_c , and mean watershed slope, S_c , were determined by using Civil 3d and are summarized in [Appendix B](#).
 - The peak discharges were found using an antecedent moisture condition (AMC) of II to represent normal conditions.
 - Calculated the peak discharges for the 10 and 100-year, 24-hour storm events. The results of the HydroCAD models are located in [Appendix C](#).
- Culvert Design and Calculations:
 - Design storm for culverts will be the 100-year, 24-hour storm.
 - Minimum culvert diameter is 30 inches and the material should be HDPE or CMP.
 - Maximum headwater for culvert design was set to 1.5 x culvert diameter.
 - Culvert capacity calculations completed using the FHWA HY-8 program.
 - Inlet and outlets shall be protected with riprap for all culverts.
 - If culvert outlet velocities exceed 10 ft/s then grouted riprap or gunite shall be used for protection.
- Channel Analysis:
 - Calculated using the FHWA Hydraulic Toolbox program.
 - A minimum freeboard of 12 inches was used for all permanent swales and channels.
 - Maximum velocity for unlined channels set at 5 feet per second. Swales located along pond fill slopes are all riprapped to protect against scour and erosion.

- Maximum velocity for dumped riprap channels set at 10 feet per second.
- Combined peak discharges at channel reaches are less than the cumulative respective discharges due to the “routing” effect of natural channels.
- Water Surface Analysis:
 - Calculated using the HEC-RAS program.
 - Mannings “n” of 0.030 used for overbank/floodplain which corresponds to tall grass.
 - Mannings “n” of 0.035 used for main channel which corresponds to grass, shrubs & trees.

5 TECHNICAL DATA:

- The Watershed Map and Drainage Map are located in [Appendix A](#).
- Precipitation depths are per the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation Frequency Estimates (NOAA, 2006) for 32.0852 ° Latitude, -110.0411 ° Longitude.
- The watershed characteristic summary for all watersheds can be found in [Appendix B](#).
- The HydroCAD peak discharge calculations are located in [Appendix C](#).
- The HY-8 Culvert Analysis is located in [Appendix D](#).
- The FHWA Channel Analysis summary is located in [Appendix E](#).
- The Riprap apron design is located in [Appendix F](#).
- The HEC-RAS calculations are located in [Appendix G](#).

RESULTS & CONCLUSIONS:

Analysis of the existing topography and proposed drainage patterns identified seventeen watersheds (Appendix A) contributing to the project area. These watersheds were analyzed using HydroCAD and the results are shown in Table 1 for each watershed.

Table 1: Watershed Characteristics

Watershed ID	Area (ac)	Lc (ft)	Avg. Sc (ft/ft)	Tc (min)	Q100 (cfs)
1	6.70	909.0	0.0716	9.00	25.45
2A	2.22	N/A	N/A	5.00	9.57
2B	2.79	599.0	0.0772	6.21	11.44
3A	1.62	602.0	0.1576	5.00	6.99
3B	0.82	649.0	0.1250	5.20	3.51
3C	1.23	603.0	0.0583	7.18	4.96
4	4.64	1122.0	0.0263	13.85	17.85
5	11.51	1049.0	0.1000	6.73	55.18
6	3.29	742.0	0.1133	5.65	14.67
7	2.42	561.0	0.0762	5.00	11.98
8A	4.10	955.0	0.0820	8.75	15.69
8B	2.89	1205.0	0.0990	8.57	12.17
9	2.48	770.0	0.0630	8.40	9.63
10	3.15	321.0	0.1174	5.00	16.97
11	3.76	1309.0	0.0600	12.22	13.66
12	0.26	N/A	N/A	5.00	1.26
13	0.47	N/A	N/A	5.00	2.13
14	99.74	3943.0	0.0514	34.37	192.93
15	13.95	2332.0	0.0509	21.87	37.01
16	6.33	573.0	0.0200	9.28	28.10
17	9.57	2089.0	0.1001	14.28	31.58
18	1.25	N/A	N/A	5.00	6.33
19	1.31	N/A	N/A	5.00	5.65
20	1.07	523.0	0.0758	5.62	4.50
21	1.90	620.0	0.0715	6.63	7.78

In the plant site, there are a number of self-contained watersheds, for these watersheds the peak discharge and volumes were calculated. These volumes will be accounted for in the overall capacity of the ponds. These watersheds were analyzed using HydroCAD and the results are shown in Table 2 for each watershed.

Table 2: Self-Contained Watershed Characteristics

Watershed ID	Area (ac)	Q100 (cfs)	V100 (ac-ft)
SOLIDS POND #1	16.41	91.54	4.999
SOLIDS POND #2	16.41	91.54	4.999
TANK FARM	3.59	17.26	0.871
RAFFINATE POND	3.04	16.96	0.926
PLS POND	3.04	16.96	0.926
WATER TREATMENT PONDS	1.63	9.09	0.497
EVAP POND #1	8.25	45.58	2.435

South of the plant site there is a natural watershed that will impact the fill slopes of the PLS Pond and water treatment ponds. In order to determine the water surface elevations (WSELs) in the natural channel, the peak discharges were calculated for the associated watersheds. These watersheds were analyzed using HydroCAD and the results are shown in Table 3.

Table 3: Natural Watershed Characteristics

Watershed ID	Area (ac)	Lc (ft)	Avg. Sc (ft/ft)	Tc (min)	Q100 (cfs)
OFF 1	40.04	2598.0	0.0866	18.96	111.25
OFF 2	10.40	1075.0	0.0906	9.15	39.22
OFF 3	4.75	827.0	0.0507	9.92	17.46

In several location near the proposed ponds, the natural drainageways are blocked creating artificial ponds. These artificial ponds were analyzed to determine the capacity to hold the 100-year event and to determine the WSEL during the design storm. The results of the HydroCAD analysis are summarized in Table 4.

Table 4: Ponded Volume Summary

Pond Location	V100 Req'd (cu-ft)	Volume Provided w/ 1' FB (cu-ft)	WSEL (ft)	Bottom of Pond (ft)	Top of Pond (ft)
WS 1	59,511	542,241	4734.36	4730.00	4743.00
WS 2A	19,719	51,137	4739.89	4736.00	4743.00
WS 3B	7,283	5,773	4782.22 ¹	4779.00	4783.00

¹ If Pond 3B is overtopped it will be conveyed around solids pond via WS 3A swale.

Due to the constraints imposed by the proposed grading improvements and existing terrain, several culverts will have to be installed to adequately relieve on-site watersheds. A summary of the culverts including location and quantity is summarized in Table 5. The HY-8 calculations are included in [Appendix D](#).

Table 5: Culvert Summary

Culvert No.	Inlet Elev. (ft)	Outlet Elev. (ft)	Length (ft)	Slope (ft/ft)	HW Elev. (ft)	Overtop Elev. (ft)	Q100 (cfs)	Velocity (ft/s)	Qty & Diameter
1	4800.0	4794.0	200.0	0.03	4803.24	4805.0	55.81	10.21	1 – 48" CMP
2	4770.0	4767.0	116.0	0.0259	4773.61	4775.0	64.68	10.00	1 – 48" CMP
3	4770.0	4767.0	220.0	0.0136	4772.24	4777.0	17.25	6.08	1 – 30" CMP
4	4767.9	4763.1	152.0	0.0316	4771.65	4783.1	137.01	11.01	2 – 48" CMPs
5	4760.65	4756.0	245.5	0.0189	4762.30	4765.0	12.19	5.90	1 – 30" CMP

The drainage swale and channel sizes determined by the FHWA Hydraulic Toolbox program are summarized below in Table 6. The swales and channels described in the table are shown in [Appendix A](#) and the full results are included in [Appendix E](#). One channel, located in WS 10 will need a riprap apron to disperse the flow before entering the stormwater pond. A riprap apron was designed to dissipate the excess velocity and the design dimensions are listed in Table 7 and calculations are included in [Appendix F](#).

Table 6: Channel Analysis Results

WS Location	Q100 (cfs)	Sideslope (H:1V)	Bottom Width (ft)	Channel Design Slope (ft/ft)	Water Depth (ft)	Channel Depth (ft)	Channel Velocity (ft/s)	Channel Lining
2B	11.44	2	0.0	0.0538	1.00	2.00	5.75	RIPRAP, D50 = 8"
3A	6.99	2	0.0	0.0250	0.84	2.00	4.91	NONE ¹
3C	4.96	2	0.0	0.0100	0.88	2.00	3.20	NONE
4	17.85	2	0.0	0.0150	1.50	2.50	3.98 ²	RIPRAP, D50 = 6"
5	55.18	2	3.0	0.0100	1.84	3.00	4.50 ²	RIPRAP, D50 = 6"
6	69.08	2	4.0	0.0237	1.52	2.67	6.48	RIPRAP, D50 = 8"
7	11.98	2	0.0	0.0331	1.11	2.25	4.85 ²	RIPRAP, D50 = 6"
8A	118.24	2	5.0	0.0238	1.84	3.00	7.42	RIPRAP, D50 = 8"
8B	12.17	2	0.0	0.0100	1.23	2.25	4.00	NONE ¹
9	26.36	2	0.0	0.0610	1.33	2.50	7.43	RIPRAP, D50 = 6"
10	135.54	2	5.0	0.0167	2.15	4.00	6.77	RIPRAP, D50 = 8"
11	18.23	2	0.0	0.0289	1.33	2.33	5.12	RIPRAP, D50 = 6"
12 & 13	2.13	2	0.0	0.0800	0.49	1.50	4.38 ²	RIPRAP, D50 = 6"
15	55.51	2	3.0	0.0208	1.54	3.00	5.91	RIPRAP, D50 = 8"
17	165.57	2	5.0	0.0141	2.48	4.00	6.71	RIPRAP, D50 = 8"
19	5.65	2	0.0	0.0100	0.93	2.00	3.30	NONE
20	4.50	2	0.0	0.0339	0.68	1.75	4.93	NONE ¹
21	7.78	2	0.0	0.0176	0.94	2.00	4.42	NONE ¹

¹ If slope is steeper than design slope indicated dumped riprap armor (D50 = 6") will be required.

² Velocity is determined using manning's n of riprap. Velocity using earthen n is greater than 5 ft/s.

Table 7: Riprap Apron Results

Apron ID	Location	Basin Sideslope (H:1V)	Apron Length (ft)	Apron Width @ Bgn (ft)	Apron Width @ End (ft)	Riprap Depth (ft)	Outlet Velocity (ft/s)	Riprap Size
A	WS 10	2	25.00	15.00	31.67	1.67	4.04	D50 = 8"

The water surface elevations determined by the HEC-RAS analysis are summarized below in Table 8. The sections listed are shown in [Appendix A](#) and the full results are included in [Appendix G](#).

Table 8: HEC-RAS Results

HECRAS Stationing	Map ID	Q Total (cfs)	Min. Channel Elev. (ft)	WS Elev. (ft)	Velocity (ft/s)
2300	A – A	111.25	4781.36	4782.07	3.46
2200	B – B	111.25	4778.97	4779.95	3.97
2000	C – C	111.25	4774.16	4775.00	4.35
1600	D – D	111.25	4765.79	4766.80	4.48
1450	E – E	150.50	4762.40	4763.58	3.72
1350	F – F	150.50	4761.35	4762.32	3.48
1100	G – G	168.00	4757.20	4757.79	3.71
1000	H – H	168.00	4754.56	4755.52	3.27
900	I – I	168.00	4753.03	4753.85	3.82

REFERENCES:

Bonin, GM, Martin, D., Lin, B., Parzybok, T., Yekta, M., and Riley, D., 2000. Precipitation Frequency Atlas of the United States, NOAA Atlas 14 Addendum, Volume 1, Version 4.0: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah) Addendum – Update to Version 3.0. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Silver Spring, Maryland, 2004 revised 2006.

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SCS, 1982. [Draft] Computer Program Co. Project Formulation – Hydrology. Soil Conservation Service Technical Release 20. Washington, DC.

LIST OF APPENDICES

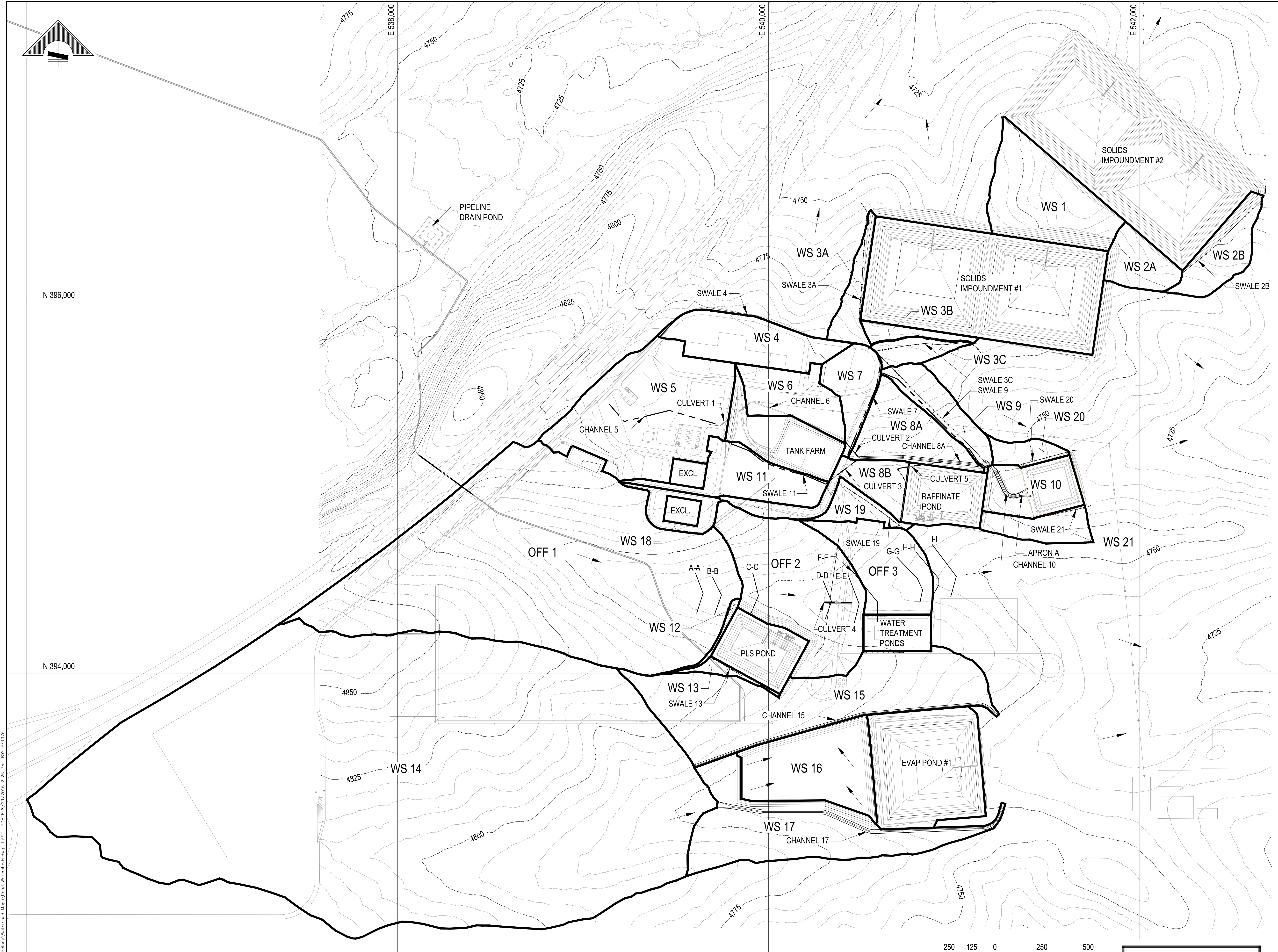
APPENDIX	DESCRIPTION
A	WATERSHED MAP
B	WATERSHED CHARACTERISTICS SUMMARY
C	HYDROCAD ANALYSIS RESULTS
D	FHWA HY-8 CULVERT ANALYSIS RESULTS
E	FHWA HYDRAULIC TOOLBOX CHANNEL ANALYSIS RESULTS
F	RIPRAP APRON ANALYSIS RESULTS
G	HEC-RAS ANALYSIS RESULTS



APPENDIX A – WATERSHED MAP



M3-PN160076
29 AUG 2016
Revision 2

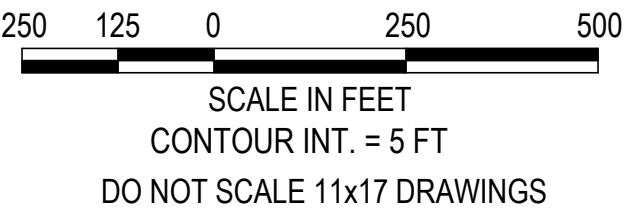


WATERSHED CHARACTERISTICS		
WS ID	AREA (ac)	Q100 (cfs)
1	6.70	25.45
2A	2.22	9.57
2B	2.79	11.44
3A	1.62	6.99
3B	0.82	3.51
3C	1.23	4.96
4	4.64	17.85
5	11.51	55.18
6	3.29	14.67
7	2.42	11.98
8A	4.10	15.69
8B	2.89	12.17
9	2.48	9.63
10	3.15	16.97
11	3.76	13.66
12	0.26	1.26
13	0.47	2.13
14	99.74	192.93
15	13.95	37.01
16	6.33	28.10
17	9.57	31.58
18	1.25	6.33
19	1.31	5.65
20	1.07	4.50
21	1.90	7.78
OFF 1	40.04	111.25
OFF 2	10.40	39.22
OFF 3	4.75	17.46

SELF-CONTAINED WATERSHED CHARACTERISTICS			
WS ID	AREA (ac)	Q100 (cfs)	V100 (ac-ft)
SOLIDS IMPOUNDMENT #1	16.41	91.54	4.99
SOLIDS IMPOUNDMENT #2	16.41	91.54	4.99
TANK FARM	3.59	17.26	0.87
RAFFINATE POND	3.04	16.96	0.93
PLS POND	3.04	16.96	0.93
WATER TREATMENT PONDS	1.63	9.09	0.50
EVAPORATION POND #1	8.25	45.58	2.435

WATER SURFACE ELEVATIONS		
SECTION ID	WSEL (ft)	V (ft/s)
A - A	4782.07	3.46
B - B	4779.95	3.97
C - C	4775.00	4.35
D - D	4766.80	4.48
E - E	4763.58	3.72
F - F	4762.32	3.48
G - G	4757.79	3.71
H - H	4755.52	3.27
I - I	4753.85	3.82

PLAN
SCALE: 1:250



PRELIMINARY
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GUNNISON COPPER CIVIL WATERSHED MAP

PROJECT NO. M3-PM 160076
DWG NO. **APPENDIX A**
REV NO. 2 DATE 29 AUG 16

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																DESIGNED BY	AJE JUL 16	
																DRAWN BY	AJE JUL 16	
																CHECKED BY		
																PROJECT MGR		
																CLIENT APPR.		

m3 ARCHITECTURE
ENGINEERING
CONSTRUCTION MANAGEMENT
M3ENG.COM

SCALE: 1:250

DESIGNED BY AJE JUL 16

DRAWN BY AJE JUL 16

CHECKED BY

PROJECT MGR

CLIENT APPR.

APPENDIX B – WATERSHED CHARACTERISTICS SUMMARY



M3-PN160076
29 AUG 2016
Revision 2

WATERSHED SUMMARY

Adam Edwards
8/29/16

PLANT SITE WATERSHEDS

Watershed ID	Area square feet	Area acres	L _c ft	S _c ft	T _c Method	T _c min	SCS CN	Impervious Area CN = 98 acres	Desert Shrub, HSG C Poor CN = 85 acres	Newly Graded, HSG C CN = 91 acres	Q ₁₀ cfs	Q ₁₀₀ cfs
--					--							
1	291,638	6.70	909.0	0.0716	SCS Lag	9.00	86	0.67	6.03	0.00	14.68	25.45
2A	96,673	2.22	N/A	N/A	Min T _c	5.00	86	0.22	2.00	0.00	5.55	9.57
2B	121,460	2.79	599.0	0.0772	SCS Lag	6.21	86	0.28	2.51	0.00	6.69	11.44
3A	70,670	1.62	602.0	0.1576	SCS Lag	5.00	86	0.16	1.46	0.00	4.05	6.99
3B	35,530	0.82	649.0	0.1250	SCS Lag	5.20	86	0.08	0.73	0.00	2.03	3.51
3C	53,488	1.23	603.0	0.0583	SCS Lag	7.18	86	0.12	1.11	0.00	2.87	4.96
4	202,283	4.64	1,122.0	0.0263	SCS Lag	13.85	92	0.46	0.00	4.18	11.28	17.85
5	501,174	11.51	1,049.0	0.10	SCS Lag	6.73	92	1.15	0.00	10.35	35.10	55.18
6	143,250	3.29	742.0	0.1133	SCS Lag	5.65	88	0.33	1.97	0.99	8.77	14.67
7	105,603	2.42	561.0	0.0762	SCS Lag	5.00	91	0.24	0.48	1.70	7.51	11.98
8A	178,763	4.10	955.0	0.0820	SCS Lag	8.75	86	0.41	3.69	0.00	9.06	15.69
8B	125,931	2.89	1,205.0	0.0990	SCS Lag	8.57	89	0.29	1.16	1.45	7.38	12.17
9	108,119	2.48	770.0	0.063	SCS Lag	8.40	86	0.25	2.23	0.00	5.56	9.63
10	137,427	3.15	321.0	0.1174	SCS Lag	5.00	95	1.58	0.00	1.58	11.24	16.97
11	163,622	3.76	1,309.0	0.0600	SCS Lag	12.22	88	0.38	2.25	1.13	8.12	13.66
12	11,433	0.26	N/A	N/A	Min T _c	5.00	89	0.03	0.10	0.13	0.78	1.26
13	20,495	0.47	N/A	N/A	Min T _c	5.00	87	0.05	0.38	0.05	1.26	2.13
14	4,344,764	99.74	3,943.0	0.0514	SCS Lag	34.37	86	9.97	89.77	0.00	109.23	192.93
15	607,849	13.95	2,332.0	0.0509	SCS Lag	21.87	87	1.40	11.86	0.70	21.46	37.01
16	275,560	6.33	573.0	0.02	SCS Lag	9.28	92	0.63	0.00	5.69	17.82	28.10
17	416,850	9.57	2,089.0	0.1001	SCS Lag	14.28	87	0.96	8.13	0.48	18.41	31.58
18	54,430	1.25	N/A	N/A	SCS Lag	5.00	92	0.12	0.00	1.12	4.03	6.33
19	57,241	1.31	N/A	N/A	SCS Lag	5.00	86	0.13	1.18	0.00	3.27	5.65
20	46,562	1.07	523.0	0.0758	SCS Lag	5.62	86	0.11	0.96	0.00	2.60	4.50
21	82,887	1.90	620.0	0.0715	SCS Lag	6.63	86	0.19	1.71	0.00	4.51	7.78

WATERSHED SUMMARY

Adam Edwards
8/29/16

SELF CONTAINED WATERSHEDS

Watershed ID	Area square feet	Area acres	L _c ft	S _c ft	Tc Method --	Tc min	SCS CN --	Impervious Area CN = 98 acres	Desert Shrub, HSG C Poor CN = 85 acres	Newly Graded, HSG C CN = 91 acres	Q ₁₀₀ cfs	V ₁₀₀ ac-ft
--												
SOLIDS POND #1	714,725	16.41	N/A	N/A	Min. Tc	5.00	98	16.41	0.00	0.00	91.54	4.999
SOLIDS POND #2	714,725	16.41	N/A	N/A	Min. Tc	5.00	98	16.41	0.00	0.00	91.54	4.999
TANK FARM	156,171	3.59	651.0	0.07	Min. Tc	5.74	91	1.36	1.51	0.72	17.26	0.871
RAFFINATE POND	132,484	3.04	N/A	N/A	Min. Tc	5.00	98	3.04	0.00	0.00	16.96	0.926
PLS POND	132,417	3.04	N/A	N/A	Min. Tc	5.00	98	3.04	0.00	0.00	16.96	0.926
WATER TREATMENT PONDS	71,175	1.63	N/A	N/A	Min. Tc	5.00	98	1.63	0.00	0.00	9.09	0.497
EVAP POND #1	359,557	8.25	N/A	N/A	Min. Tc	5.00	97	6.60	0.00	1.65	45.58	2.435

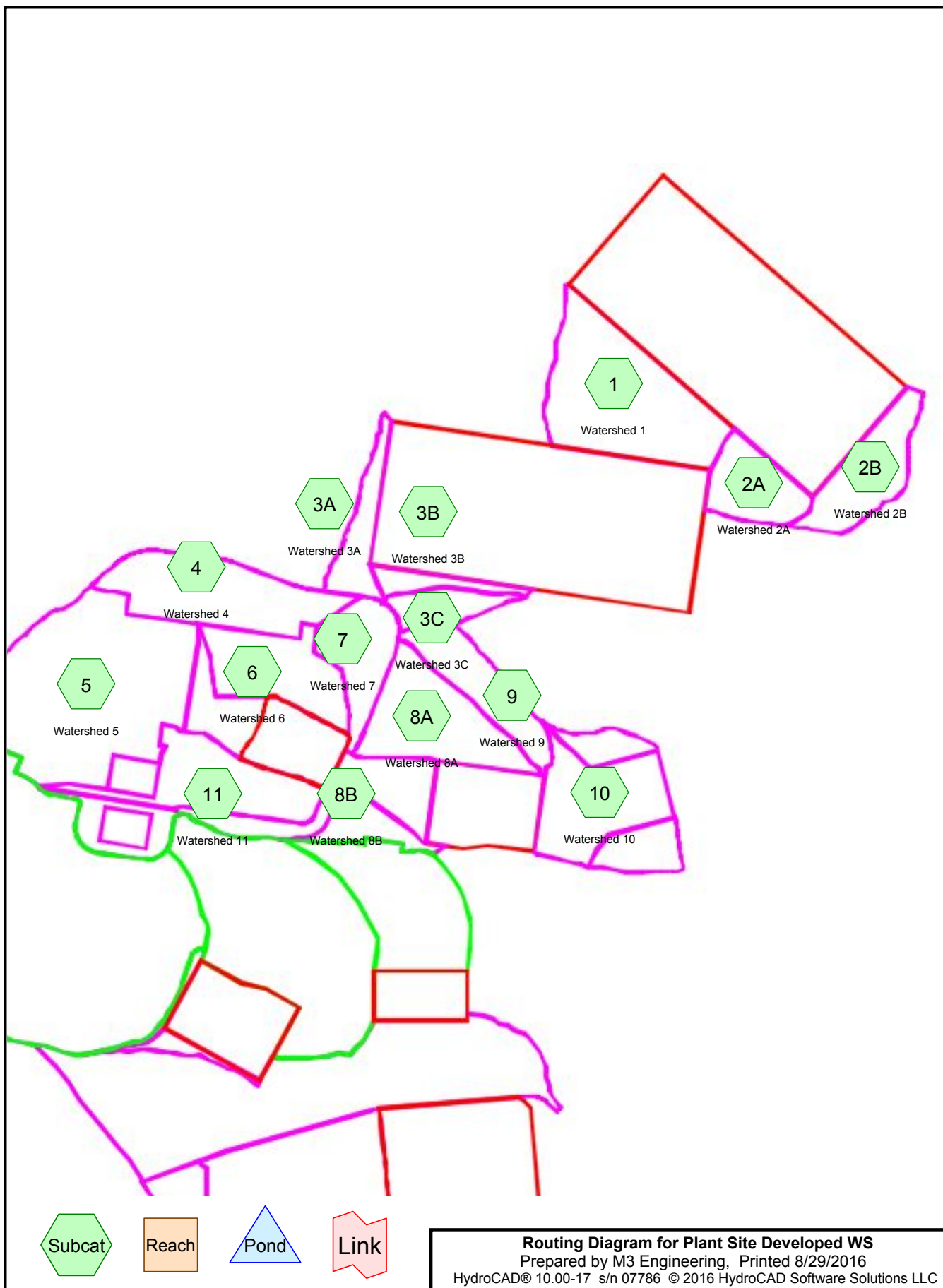
OFF SITE WATERSHEDS

Watershed ID	Area square feet	Area acres	L _c ft	S _c ft	Tc Method --	Tc min	SCS CN --	Impervious Area CN = 98 acres	Desert Shrub, HSG C Poor CN = 85 acres	Newly Graded, HSG C CN = 91 acres	Q ₁₀ cfs	Q ₁₀₀ cfs
--												
OFF 1	1,744,249	40.04	2,598.0	0.0866	SCS Lag	18.96	86	4.00	36.04	0.00	63.48	111.25
OFF 2	453,146	10.40	1,075.0	0.0906	SCS Lag	9.15	86	1.04	9.36	0.00	22.61	39.22
OFF 3	206,807	4.75	827.0	0.0507	SCS Lag	9.92	86	0.47	4.27	0.00	10.05	17.46

APPENDIX C – HYDROCAD ANALYSIS RESULTS



M3-PN160076
29 AUG 2016
Revision 2



Plant Site Developed WS

Prepared by M3 Engineering

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Page 2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
6.620	98	10% Impervious (1, 2A, 2B, 3A, 3B, 3C, 4, 5, 6, 7, 8A, 8B, 9, 10, 11)
25.620	85	Desert shrub range, Poor, HSG C (1, 2A, 2B, 3A, 3B, 3C, 6, 7, 8A, 8B, 9, 11)
21.380	91	Newly graded area, HSG C (4, 5, 6, 7, 8B, 10, 11)
53.620	89	TOTAL AREA

Plant Site Developed WS

Prepared by M3 Engineering

HydroCAD® 10.00-17 s/n 07786 © 2016 HydroCAD Software Solutions LLC

Type II 24-hr 10-YR Rainfall=2.68"

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Page 3

Time span=0.00-27.00 hrs, dt=0.05 hrs, 541 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1: Watershed 1 Runoff Area=6.700 ac 10.00% Impervious Runoff Depth=1.39"
Flow Length=909' Slope=0.0716 '/' Tc=9.0 min CN=86 Runoff=14.68 cfs 0.777 af

Subcatchment2A: Watershed 2A Runoff Area=2.220 ac 9.91% Impervious Runoff Depth=1.39"
Tc=5.0 min CN=86 Runoff=5.55 cfs 0.258 af

Subcatchment2B: Watershed 2B Runoff Area=2.790 ac 10.04% Impervious Runoff Depth=1.39"
Flow Length=599' Slope=0.0772 '/' Tc=6.2 min CN=86 Runoff=6.69 cfs 0.324 af

Subcatchment3A: Watershed 3A Runoff Area=1.620 ac 9.88% Impervious Runoff Depth=1.39"
Flow Length=602' Slope=0.1576 '/' Tc=5.0 min CN=86 Runoff=4.05 cfs 0.188 af

Subcatchment3B: Watershed 3B Runoff Area=0.820 ac 9.76% Impervious Runoff Depth=1.39"
Flow Length=649' Slope=0.1250 '/' Tc=5.2 min CN=86 Runoff=2.03 cfs 0.095 af

Subcatchment3C: Watershed 3C Runoff Area=1.230 ac 9.76% Impervious Runoff Depth=1.39"
Flow Length=603' Slope=0.0583 '/' Tc=7.2 min CN=86 Runoff=2.87 cfs 0.143 af

Subcatchment4: Watershed 4 Runoff Area=4.640 ac 9.91% Impervious Runoff Depth=1.86"
Flow Length=1,122' Slope=0.0263 '/' Tc=13.9 min CN=92 Runoff=11.28 cfs 0.719 af

Subcatchment5: Watershed 5 Runoff Area=11.500 ac 10.00% Impervious Runoff Depth=1.86"
Flow Length=1,049' Slope=0.1000 '/' Tc=6.7 min CN=92 Runoff=35.10 cfs 1.783 af

Subcatchment6: Watershed 6 Runoff Area=3.290 ac 10.03% Impervious Runoff Depth=1.54"
Flow Length=742' Slope=0.1133 '/' Tc=5.6 min CN=88 Runoff=8.77 cfs 0.421 af

Subcatchment7: Watershed 7 Runoff Area=2.420 ac 9.92% Impervious Runoff Depth=1.77"
Flow Length=561' Slope=0.0762 '/' Tc=5.0 min CN=91 Runoff=7.51 cfs 0.358 af

Subcatchment8A: Watershed 8A Runoff Area=4.100 ac 10.00% Impervious Runoff Depth=1.39"
Flow Length=955' Slope=0.0820 '/' Tc=8.8 min CN=86 Runoff=9.06 cfs 0.476 af

Subcatchment8B: Watershed 8B Runoff Area=2.890 ac 10.03% Impervious Runoff Depth=1.61"
Flow Length=1,205' Slope=0.0990 '/' Tc=8.6 min CN=89 Runoff=7.38 cfs 0.389 af

Subcatchment9: Watershed 9 Runoff Area=2.480 ac 10.08% Impervious Runoff Depth=1.39"
Flow Length=770' Slope=0.0630 '/' Tc=8.4 min CN=86 Runoff=5.56 cfs 0.288 af

Subcatchment10: Watershed 10 Runoff Area=3.160 ac 50.00% Impervious Runoff Depth=2.14"
Flow Length=321' Slope=0.1174 '/' Tc=5.0 min CN=95 Runoff=11.24 cfs 0.563 af

Subcatchment11: Watershed 11 Runoff Area=3.760 ac 10.11% Impervious Runoff Depth=1.54"
Flow Length=1,309' Slope=0.0600 '/' Tc=12.2 min CN=88 Runoff=8.12 cfs 0.482 af

Total Runoff Area = 53.620 ac Runoff Volume = 7.262 af Average Runoff Depth = 1.63"
87.65% Pervious = 47.000 ac 12.35% Impervious = 6.620 ac

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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 1: Watershed 1

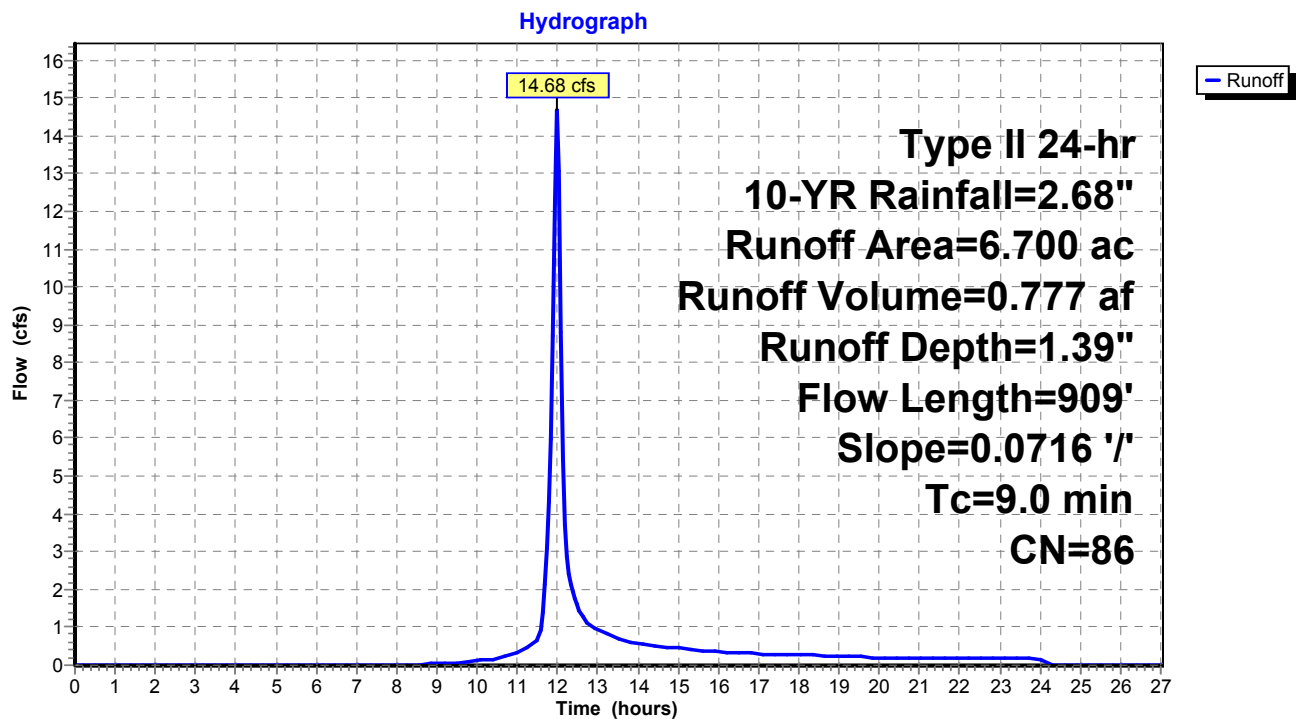
Runoff = 14.68 cfs @ 12.00 hrs, Volume= 0.777 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.670	98	10% Impervious
6.030	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
6.700	86	Weighted Average
6.030		90.00% Pervious Area
0.670		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	909	0.0716	1.68		Lag/CN Method,

Subcatchment 1: Watershed 1



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Summary for Subcatchment 2A: Watershed 2A

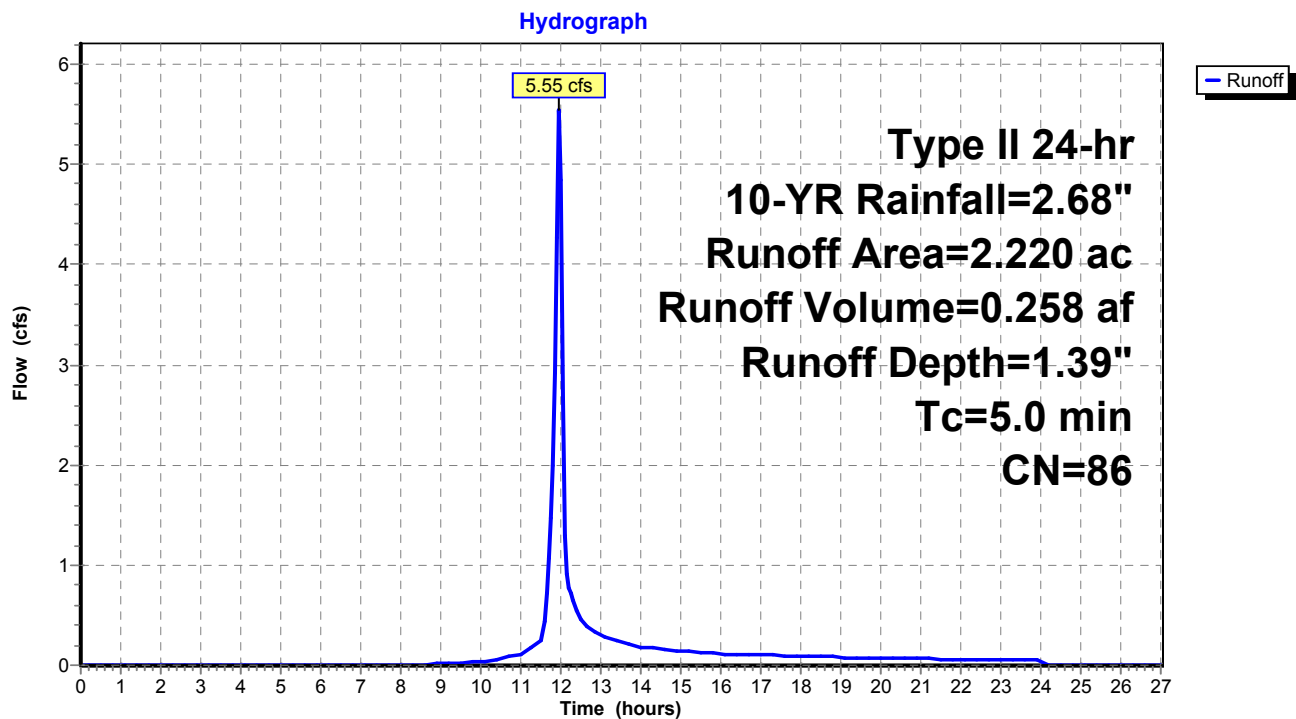
Runoff = 5.55 cfs @ 11.96 hrs, Volume= 0.258 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.220	98	10% Impervious
2.000	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
2.220	86	Weighted Average
2.000		90.09% Pervious Area
0.220		9.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 2A: Watershed 2A



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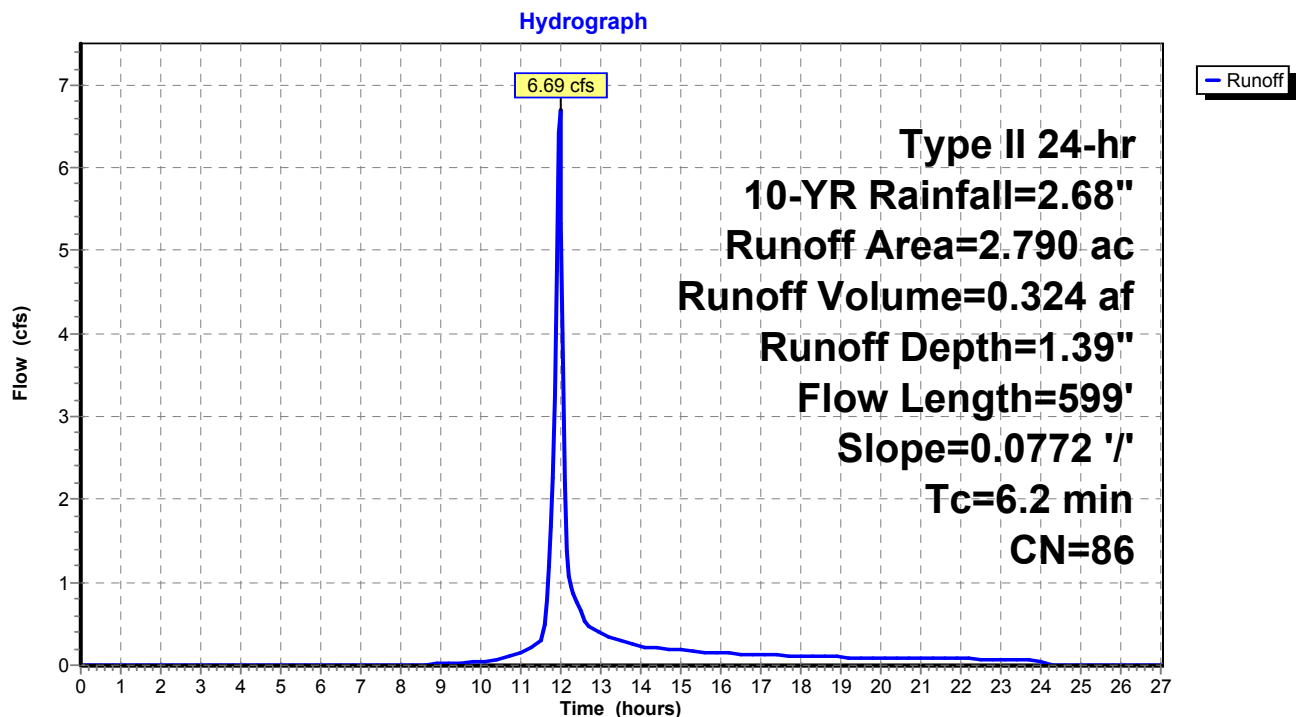
Summary for Subcatchment 2B: Watershed 2B

Runoff = 6.69 cfs @ 11.98 hrs, Volume= 0.324 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.280	98	10% Impervious
2.510	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
2.790	86	Weighted Average
2.510		89.96% Pervious Area
0.280		10.04% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	599	0.0772	1.61		Lag/CN Method,

Subcatchment 2B: Watershed 2B

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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 3A: Watershed 3A

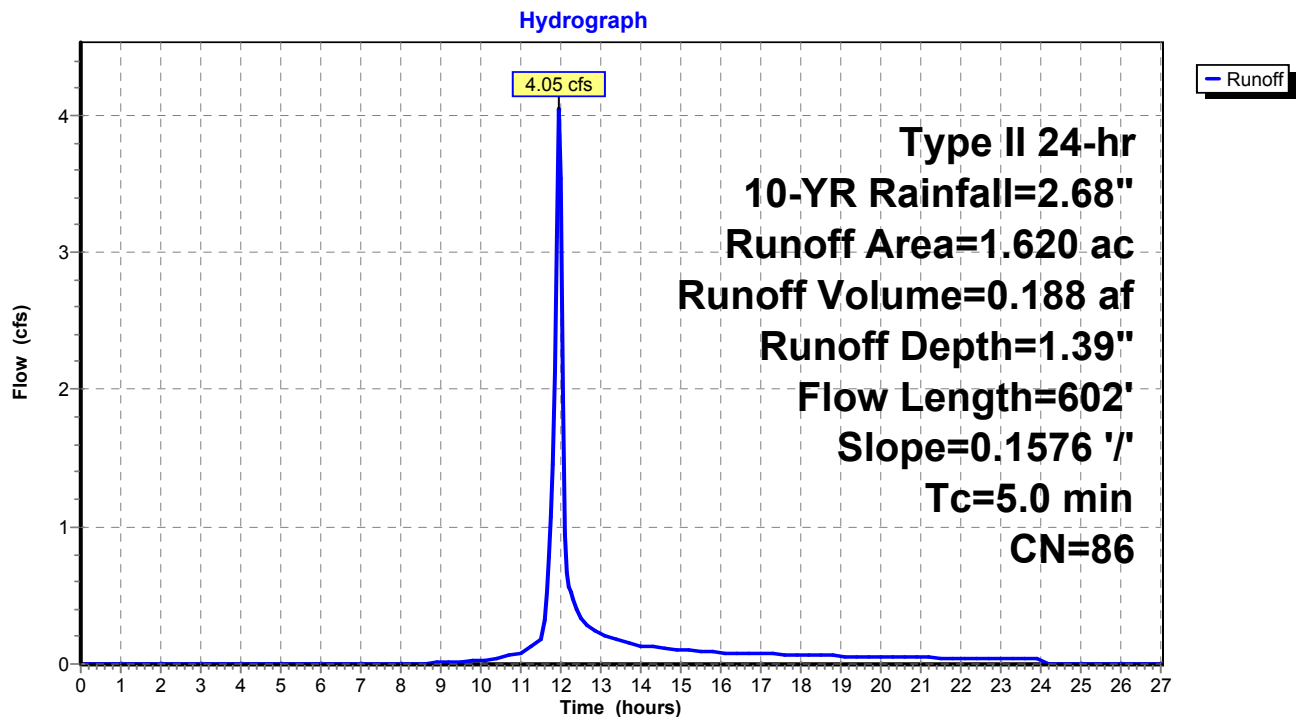
Runoff = 4.05 cfs @ 11.96 hrs, Volume= 0.188 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

	Area (ac)	CN	Description
*	0.160	98	10% Impervious
	1.460	85	Desert shrub range, Poor, HSG C
	0.000	91	Newly graded area, HSG C
	1.620	86	Weighted Average
	1.460		90.12% Pervious Area
	0.160		9.88% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.4	602	0.1576	2.30		Lag/CN Method,
4.4	602	Total, Increased to minimum Tc = 5.0 min			

Subcatchment 3A: Watershed 3A



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 3B: Watershed 3B

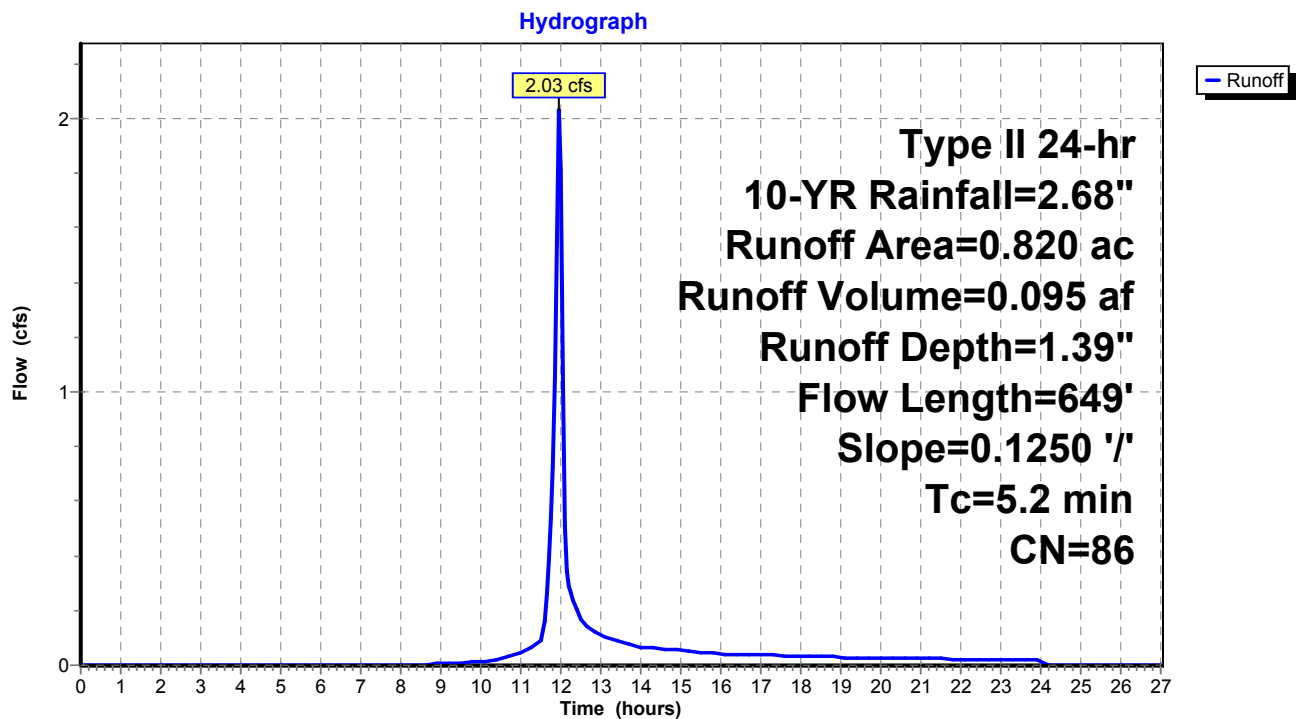
Runoff = 2.03 cfs @ 11.96 hrs, Volume= 0.095 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.080	98	10% Impervious
0.740	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
0.820	86	Weighted Average
0.740		90.24% Pervious Area
0.080		9.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2	649	0.1250	2.08		Lag/CN Method,

Subcatchment 3B: Watershed 3B



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 3C: Watershed 3C

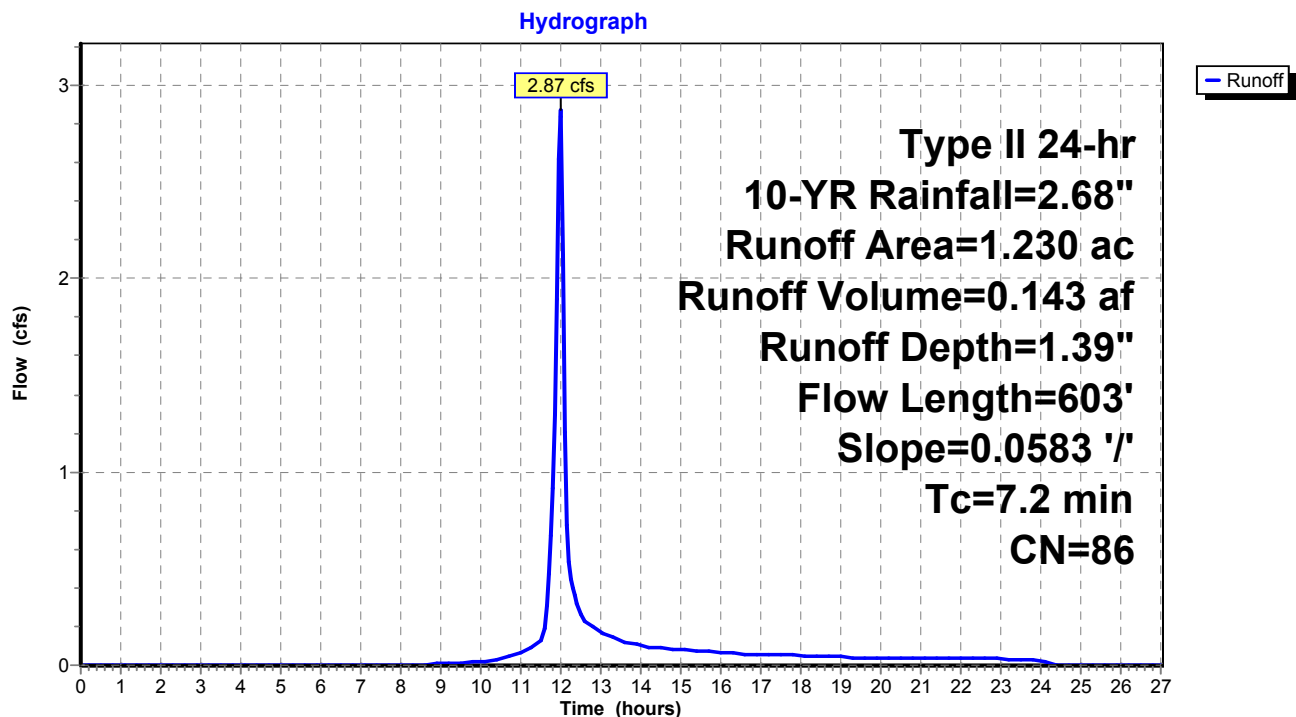
Runoff = 2.87 cfs @ 11.99 hrs, Volume= 0.143 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.120	98	10% Impervious
1.110	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
1.230	86	Weighted Average
1.110		90.24% Pervious Area
0.120		9.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.2	603	0.0583	1.40		Lag/CN Method,

Subcatchment 3C: Watershed 3C



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 4: Watershed 4

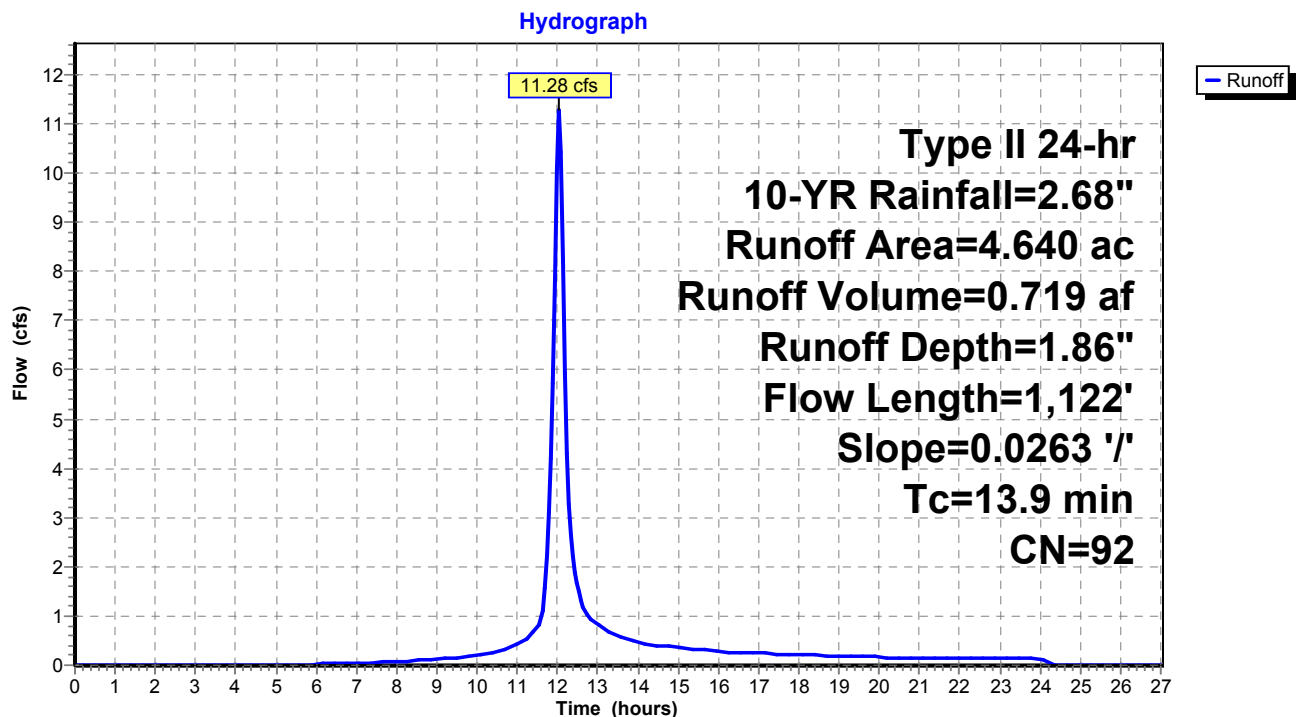
Runoff = 11.28 cfs @ 12.05 hrs, Volume= 0.719 af, Depth= 1.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.460	98	10% Impervious
0.000	85	Desert shrub range, Poor, HSG C
4.180	91	Newly graded area, HSG C
4.640	92	Weighted Average
4.180		90.09% Pervious Area
0.460		9.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.9	1,122	0.0263	1.35		Lag/CN Method,

Subcatchment 4: Watershed 4



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Type II 24-hr 10-YR Rainfall=2.68"

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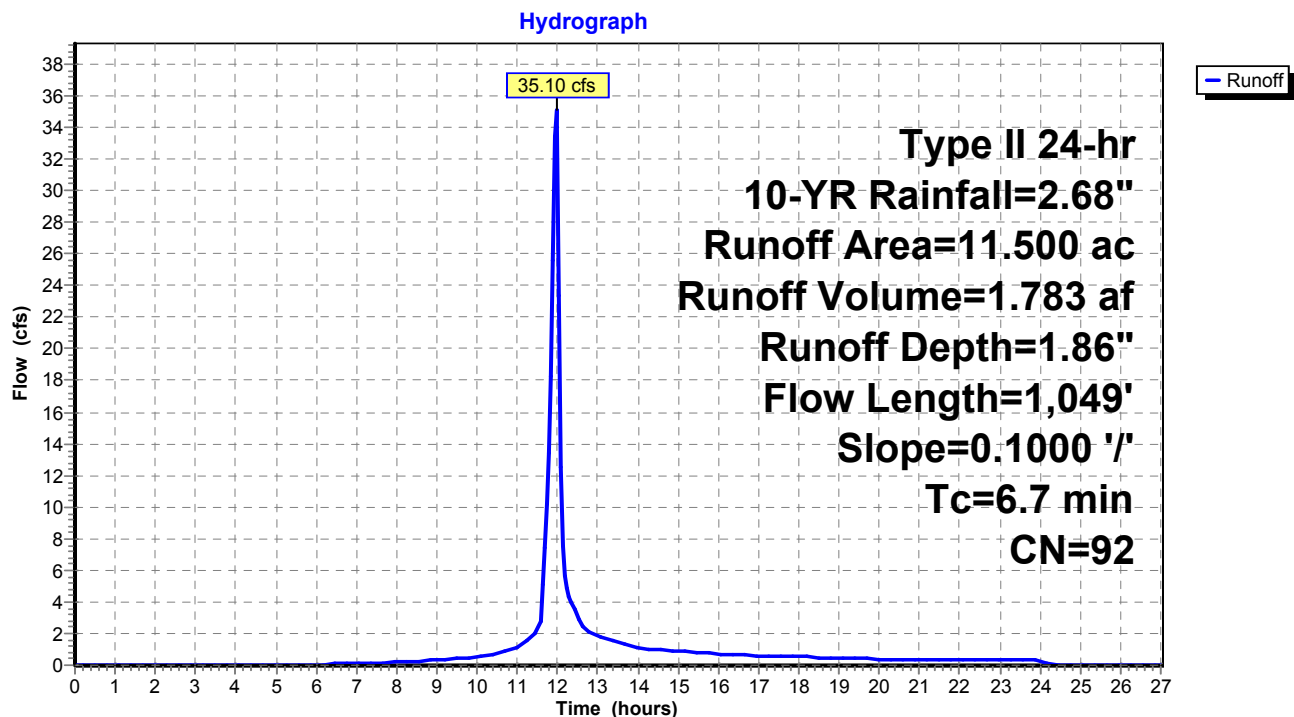
Summary for Subcatchment 5: Watershed 5

Runoff = 35.10 cfs @ 11.98 hrs, Volume= 1.783 af, Depth= 1.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 1.150	98	10% Impervious
0.000	85	Desert shrub range, Poor, HSG C
10.350	91	Newly graded area, HSG C
11.500	92	Weighted Average
10.350		90.00% Pervious Area
1.150		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	1,049	0.1000	2.60		Lag/CN Method,

Subcatchment 5: Watershed 5

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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 6: Watershed 6

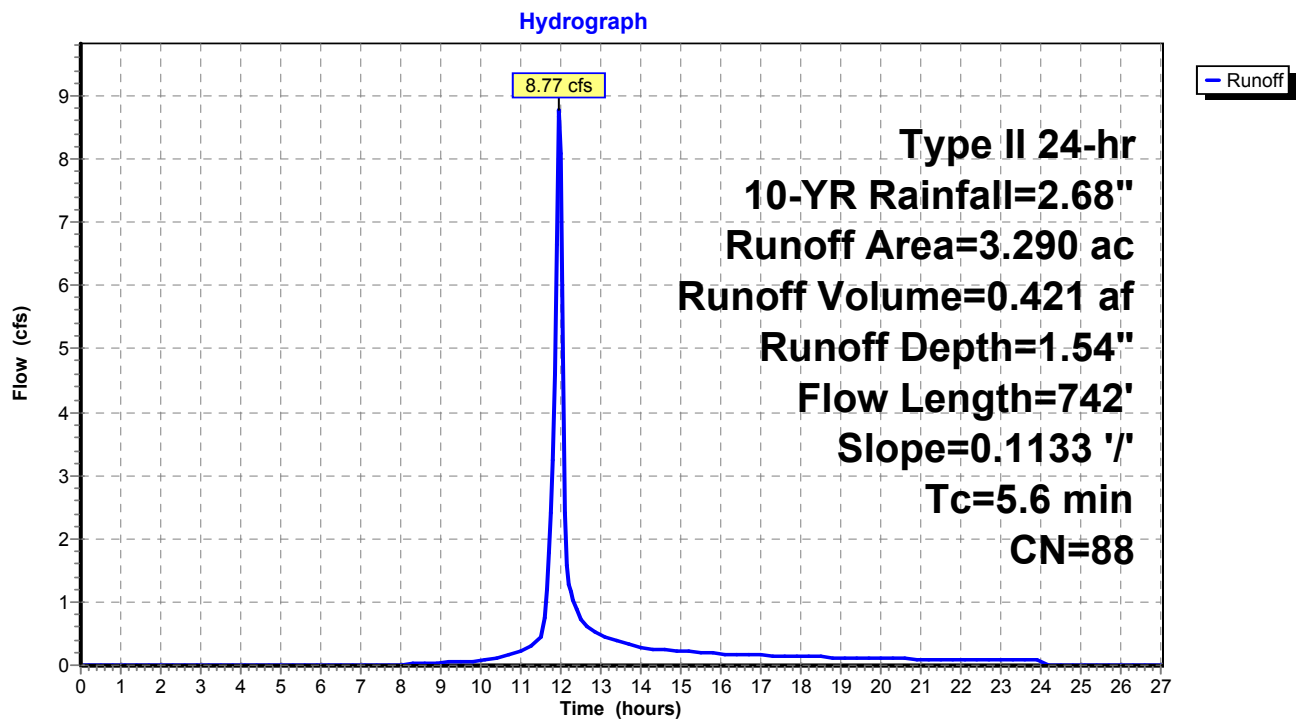
Runoff = 8.77 cfs @ 11.96 hrs, Volume= 0.421 af, Depth= 1.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.330	98	10% Impervious
1.970	85	Desert shrub range, Poor, HSG C
0.990	91	Newly graded area, HSG C
3.290	88	Weighted Average
2.960		89.97% Pervious Area
0.330		10.03% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	742	0.1133	2.19		Lag/CN Method,

Subcatchment 6: Watershed 6



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 7: Watershed 7

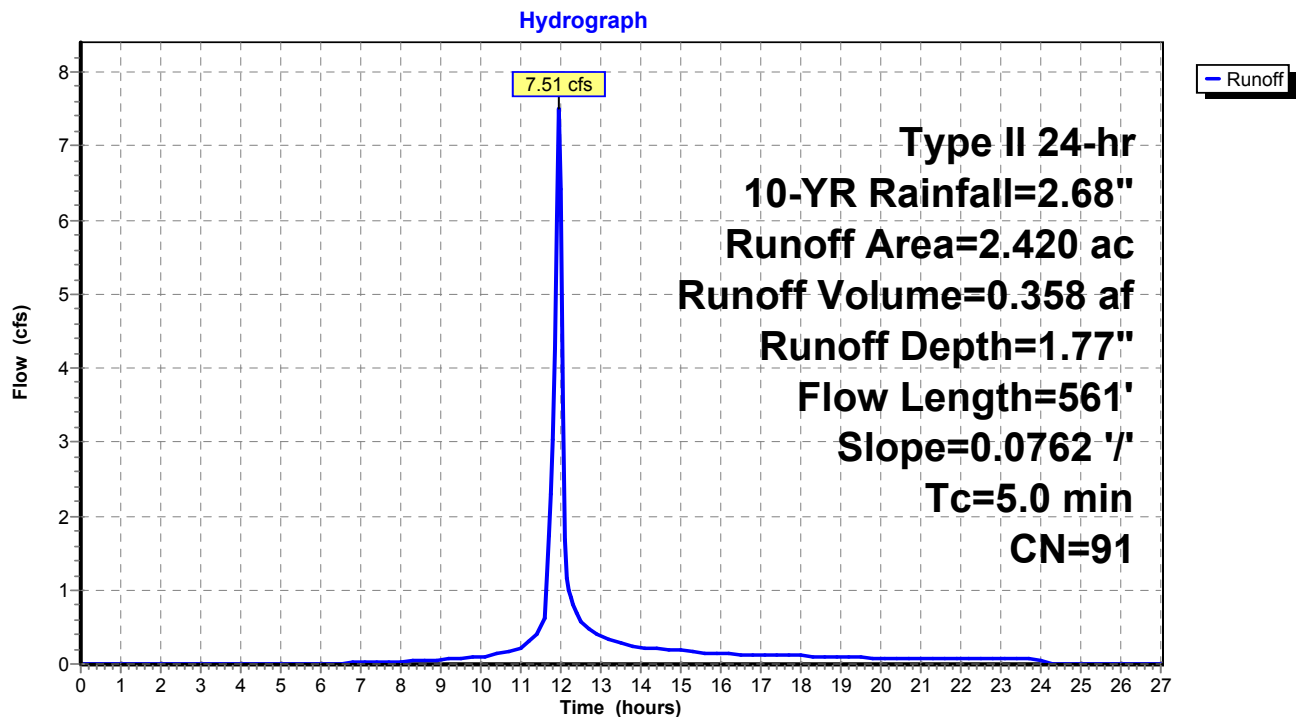
Runoff = 7.51 cfs @ 11.95 hrs, Volume= 0.358 af, Depth= 1.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.240	98	10% Impervious
0.480	85	Desert shrub range, Poor, HSG C
1.700	91	Newly graded area, HSG C
2.420	91	Weighted Average
2.180		90.08% Pervious Area
0.240		9.92% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	561	0.0762	1.92		Lag/CN Method,
4.9	561	Total, Increased to minimum Tc = 5.0 min			

Subcatchment 7: Watershed 7



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 8A: Watershed 8A

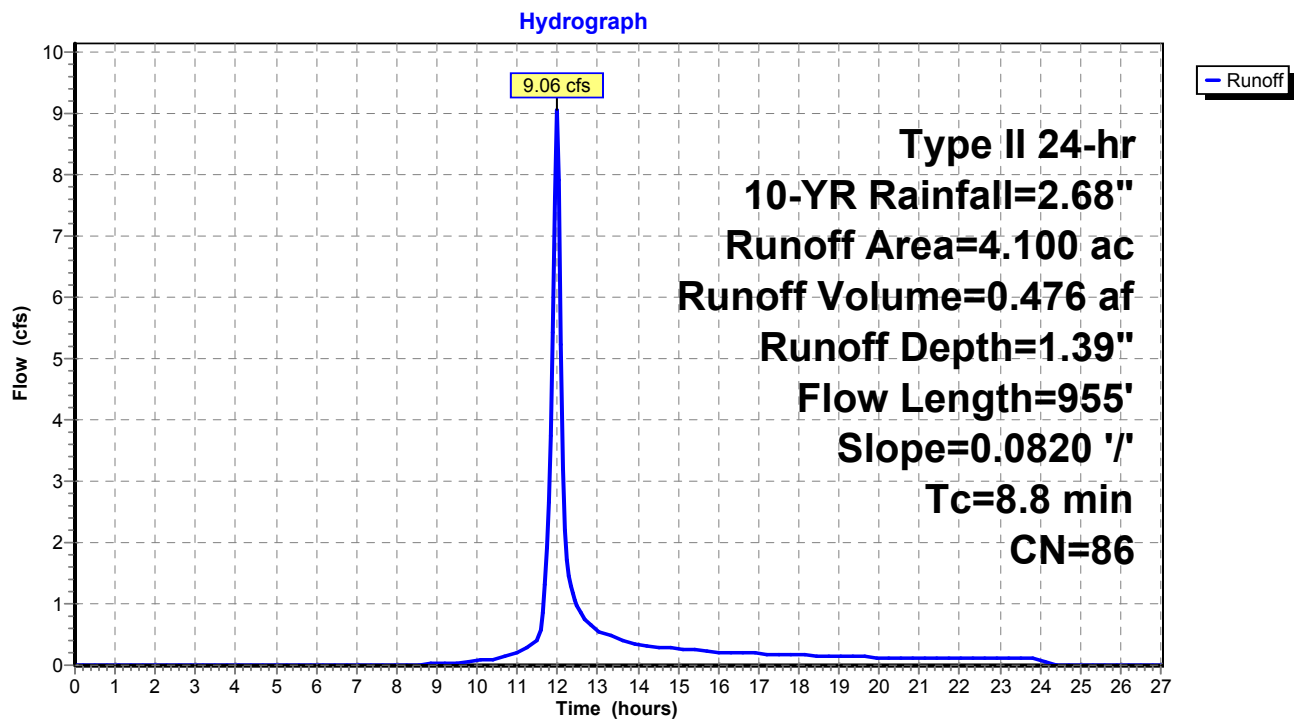
Runoff = 9.06 cfs @ 12.00 hrs, Volume= 0.476 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.410	98	10% Impervious
3.690	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
4.100	86	Weighted Average
3.690		90.00% Pervious Area
0.410		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	955	0.0820	1.82		Lag/CN Method,

Subcatchment 8A: Watershed 8A



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Type II 24-hr 10-YR Rainfall=2.68"

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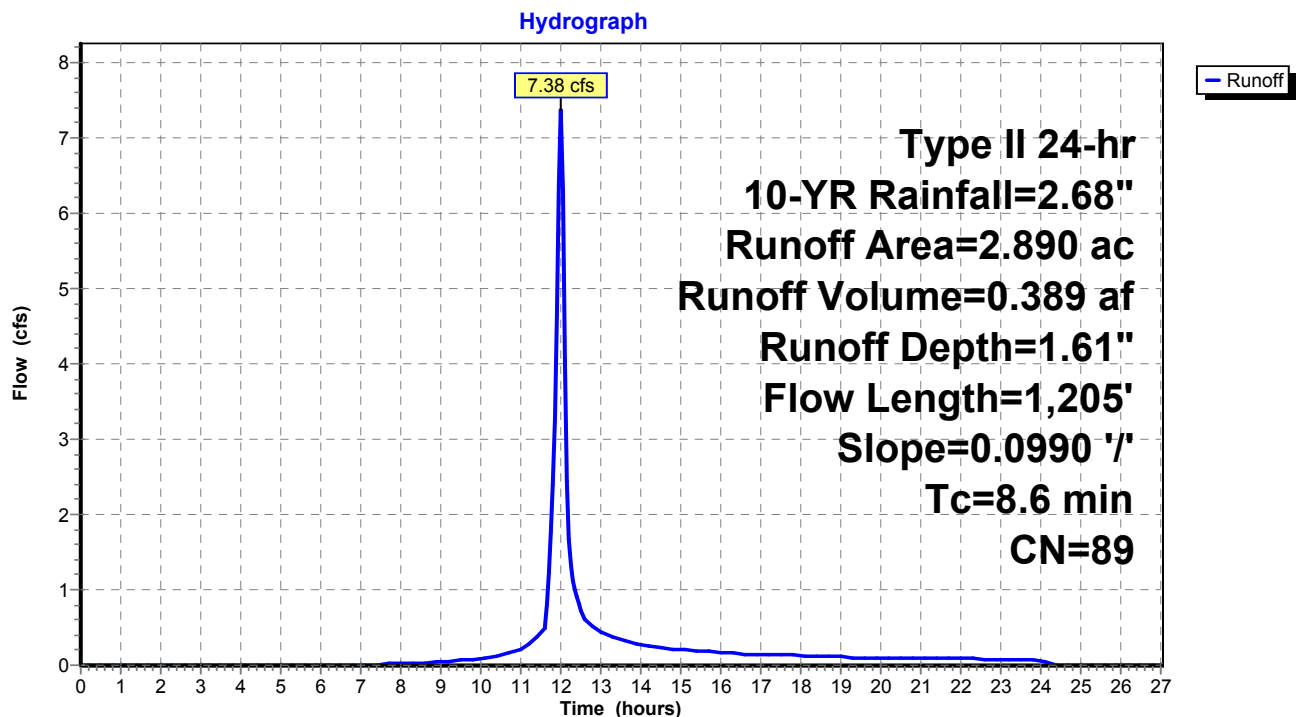
Summary for Subcatchment 8B: Watershed 8B

Runoff = 7.38 cfs @ 12.00 hrs, Volume= 0.389 af, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.290	98	10% Impervious
1.150	85	Desert shrub range, Poor, HSG C
1.450	91	Newly graded area, HSG C
2.890	89	Weighted Average
2.600		89.97% Pervious Area
0.290		10.03% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.6	1,205	0.0990	2.34		Lag/CN Method,

Subcatchment 8B: Watershed 8B

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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 9: Watershed 9

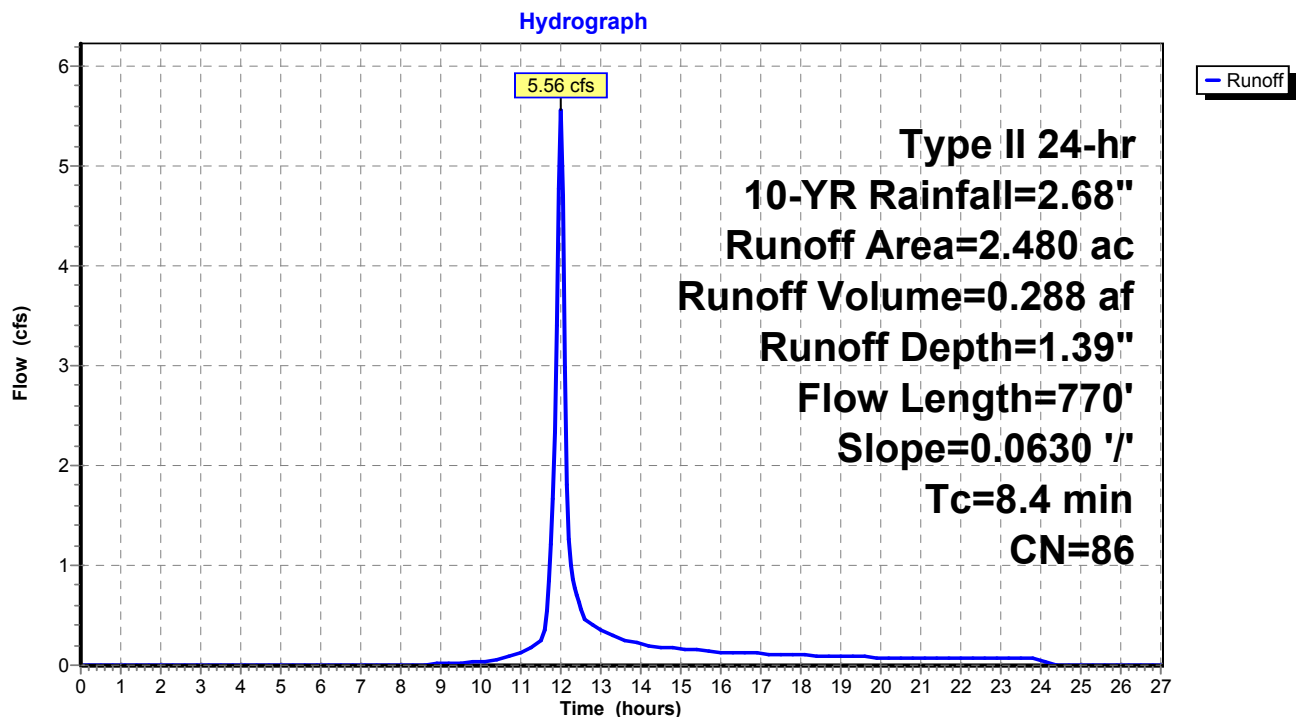
Runoff = 5.56 cfs @ 12.00 hrs, Volume= 0.288 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.250	98	10% Impervious
2.230	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
2.480	86	Weighted Average
2.230		89.92% Pervious Area
0.250		10.08% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.4	770	0.0630	1.53		Lag/CN Method,

Subcatchment 9: Watershed 9



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Type II 24-hr 10-YR Rainfall=2.68"

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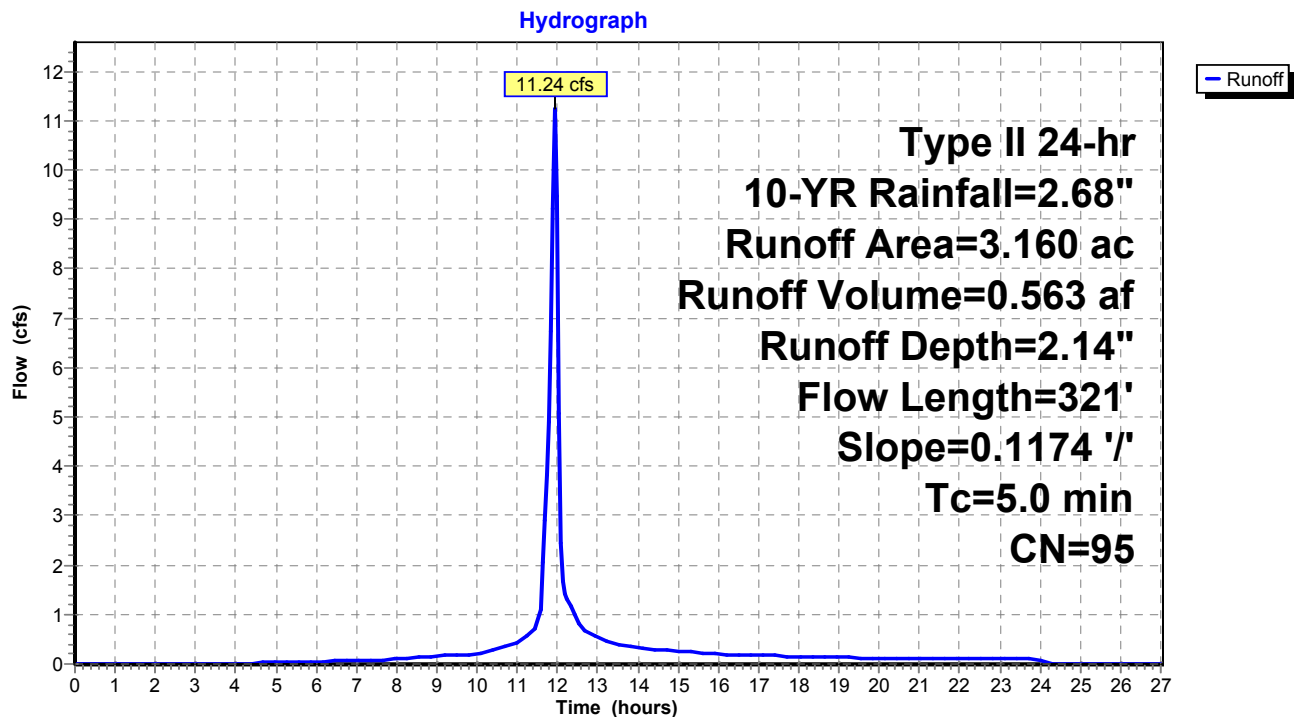
Summary for Subcatchment 10: Watershed 10

Runoff = 11.24 cfs @ 11.95 hrs, Volume= 0.563 af, Depth= 2.14"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 1.580	98	10% Impervious
0.000	85	Desert shrub range, Poor, HSG C
1.580	91	Newly graded area, HSG C
3.160	95	Weighted Average
1.580		50.00% Pervious Area
1.580		50.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1	321	0.1174	2.56		Lag/CN Method,
2.1	321	Total, Increased to minimum Tc = 5.0 min			

Subcatchment 10: Watershed 10

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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 11: Watershed 11

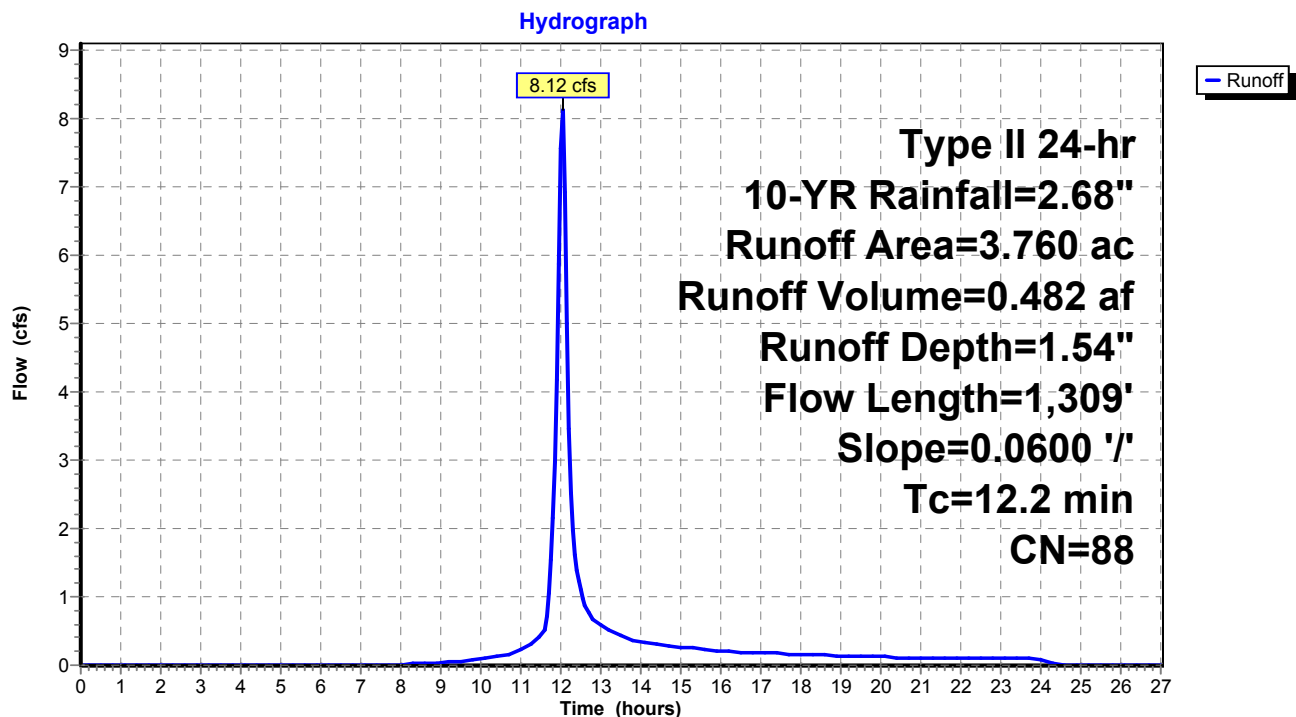
Runoff = 8.12 cfs @ 12.04 hrs, Volume= 0.482 af, Depth= 1.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

	Area (ac)	CN	Description
*	0.380	98	10% Impervious
	2.250	85	Desert shrub range, Poor, HSG C
	1.130	91	Newly graded area, HSG C
	3.760	88	Weighted Average
	3.380		89.89% Pervious Area
	0.380		10.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2	1,309	0.0600	1.78		Lag/CN Method,

Subcatchment 11: Watershed 11



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Type II 24-hr 100-YR Rainfall=3.89"

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Time span=0.00-27.00 hrs, dt=0.05 hrs, 541 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1: Watershed 1 Runoff Area=6.700 ac 10.00% Impervious Runoff Depth=2.45"
Flow Length=909' Slope=0.0716 '/' Tc=9.0 min CN=86 Runoff=25.45 cfs 1.366 af

Subcatchment2A: Watershed 2A Runoff Area=2.220 ac 9.91% Impervious Runoff Depth=2.45"
Tc=5.0 min CN=86 Runoff=9.57 cfs 0.453 af

Subcatchment2B: Watershed 2B Runoff Area=2.790 ac 10.04% Impervious Runoff Depth=2.45"
Flow Length=599' Slope=0.0772 '/' Tc=6.2 min CN=86 Runoff=11.44 cfs 0.569 af

Subcatchment3A: Watershed 3A Runoff Area=1.620 ac 9.88% Impervious Runoff Depth=2.45"
Flow Length=602' Slope=0.1576 '/' Tc=5.0 min CN=86 Runoff=6.99 cfs 0.330 af

Subcatchment3B: Watershed 3B Runoff Area=0.820 ac 9.76% Impervious Runoff Depth=2.45"
Flow Length=649' Slope=0.1250 '/' Tc=5.2 min CN=86 Runoff=3.51 cfs 0.167 af

Subcatchment3C: Watershed 3C Runoff Area=1.230 ac 9.76% Impervious Runoff Depth=2.45"
Flow Length=603' Slope=0.0583 '/' Tc=7.2 min CN=86 Runoff=4.96 cfs 0.251 af

Subcatchment4: Watershed 4 Runoff Area=4.640 ac 9.91% Impervious Runoff Depth=3.01"
Flow Length=1,122' Slope=0.0263 '/' Tc=13.9 min CN=92 Runoff=17.85 cfs 1.164 af

Subcatchment5: Watershed 5 Runoff Area=11.500 ac 10.00% Impervious Runoff Depth=3.01"
Flow Length=1,049' Slope=0.1000 '/' Tc=6.7 min CN=92 Runoff=55.18 cfs 2.886 af

Subcatchment6: Watershed 6 Runoff Area=3.290 ac 10.03% Impervious Runoff Depth=2.63"
Flow Length=742' Slope=0.1133 '/' Tc=5.6 min CN=88 Runoff=14.67 cfs 0.720 af

Subcatchment7: Watershed 7 Runoff Area=2.420 ac 9.92% Impervious Runoff Depth=2.91"
Flow Length=561' Slope=0.0762 '/' Tc=5.0 min CN=91 Runoff=11.98 cfs 0.587 af

Subcatchment8A: Watershed 8A Runoff Area=4.100 ac 10.00% Impervious Runoff Depth=2.45"
Flow Length=955' Slope=0.0820 '/' Tc=8.8 min CN=86 Runoff=15.69 cfs 0.836 af

Subcatchment8B: Watershed 8B Runoff Area=2.890 ac 10.03% Impervious Runoff Depth=2.72"
Flow Length=1,205' Slope=0.0990 '/' Tc=8.6 min CN=89 Runoff=12.17 cfs 0.655 af

Subcatchment9: Watershed 9 Runoff Area=2.480 ac 10.08% Impervious Runoff Depth=2.45"
Flow Length=770' Slope=0.0630 '/' Tc=8.4 min CN=86 Runoff=9.63 cfs 0.506 af

Subcatchment10: Watershed 10 Runoff Area=3.160 ac 50.00% Impervious Runoff Depth=3.32"
Flow Length=321' Slope=0.1174 '/' Tc=5.0 min CN=95 Runoff=16.97 cfs 0.875 af

Subcatchment11: Watershed 11 Runoff Area=3.760 ac 10.11% Impervious Runoff Depth=2.63"
Flow Length=1,309' Slope=0.0600 '/' Tc=12.2 min CN=88 Runoff=13.66 cfs 0.823 af

Total Runoff Area = 53.620 ac Runoff Volume = 12.189 af Average Runoff Depth = 2.73"
87.65% Pervious = 47.000 ac 12.35% Impervious = 6.620 ac

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 1: Watershed 1

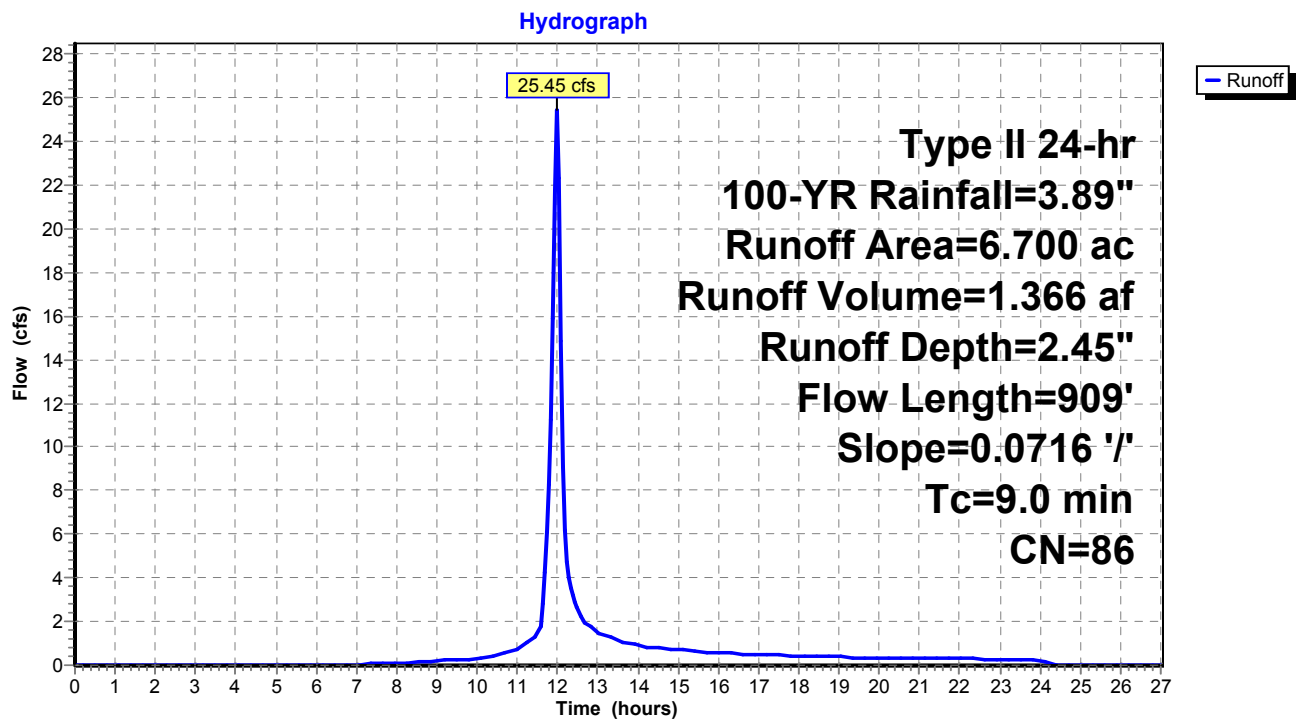
Runoff = 25.45 cfs @ 12.00 hrs, Volume= 1.366 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.670	98	10% Impervious
6.030	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
6.700	86	Weighted Average
6.030		90.00% Pervious Area
0.670		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	909	0.0716	1.68		Lag/CN Method,

Subcatchment 1: Watershed 1



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Summary for Subcatchment 2A: Watershed 2A

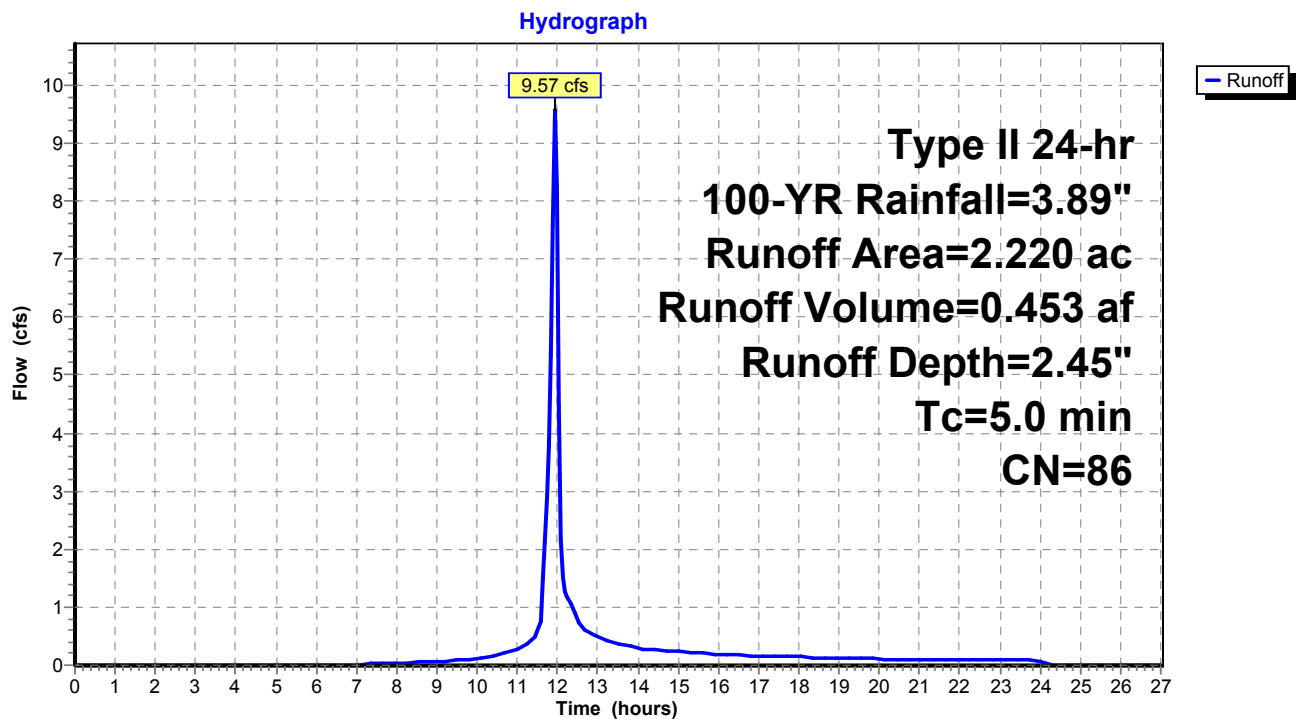
Runoff = 9.57 cfs @ 11.95 hrs, Volume= 0.453 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.220	98	10% Impervious
2.000	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
2.220	86	Weighted Average
2.000		90.09% Pervious Area
0.220		9.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 2A: Watershed 2A



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Summary for Subcatchment 2B: Watershed 2B

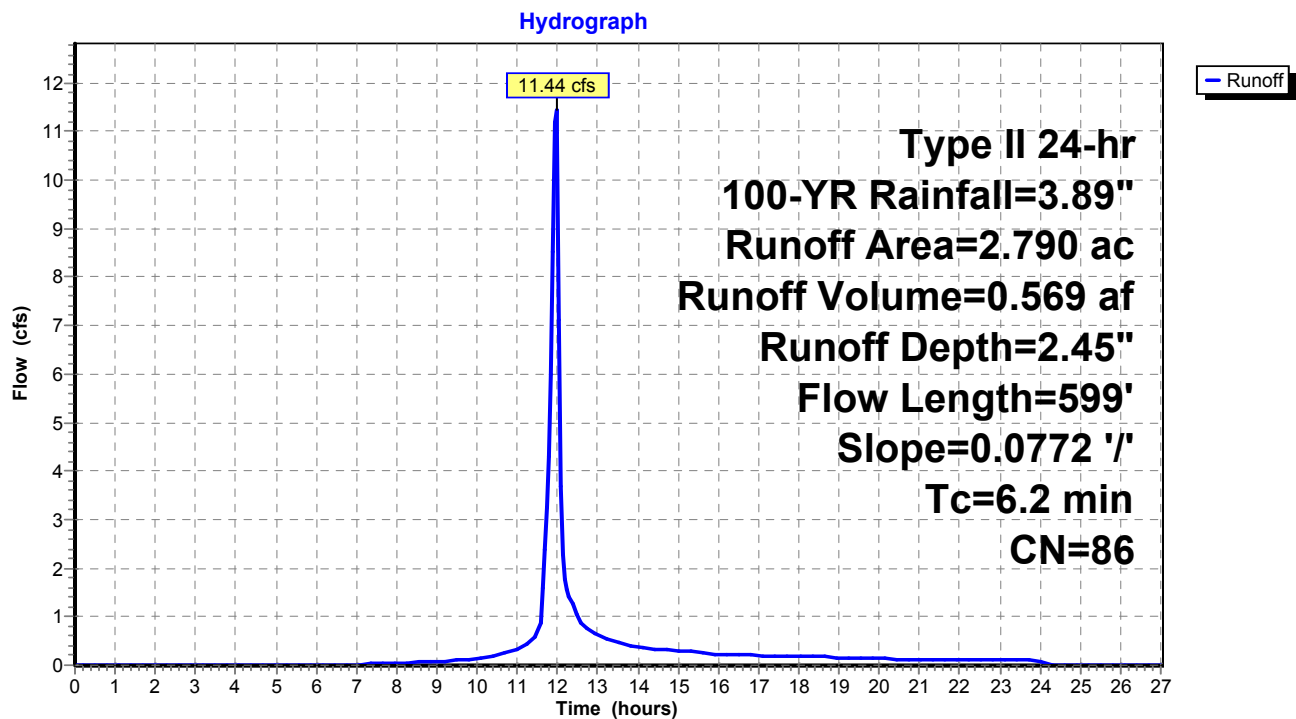
Runoff = 11.44 cfs @ 11.97 hrs, Volume= 0.569 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.280	98	10% Impervious
2.510	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
2.790	86	Weighted Average
2.510		89.96% Pervious Area
0.280		10.04% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	599	0.0772	1.61		Lag/CN Method,

Subcatchment 2B: Watershed 2B



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Summary for Subcatchment 3A: Watershed 3A

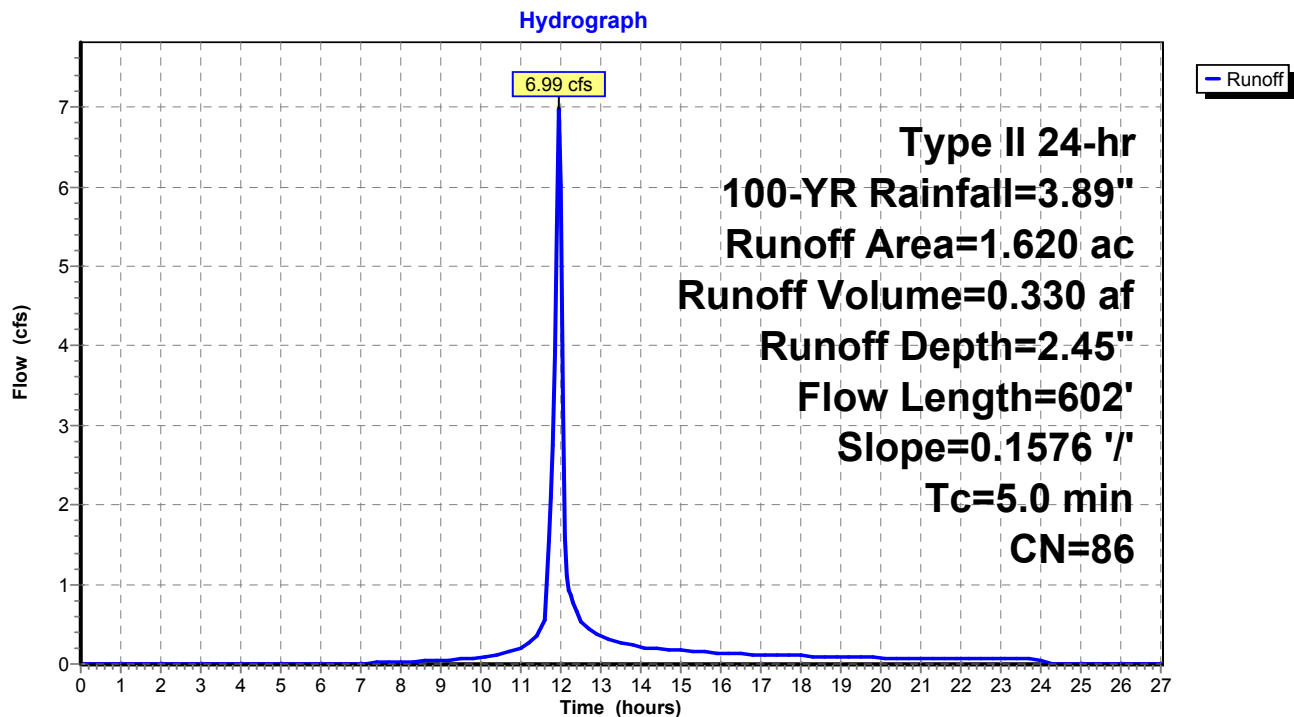
Runoff = 6.99 cfs @ 11.95 hrs, Volume= 0.330 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

	Area (ac)	CN	Description
*	0.160	98	10% Impervious
	1.460	85	Desert shrub range, Poor, HSG C
	0.000	91	Newly graded area, HSG C
	1.620	86	Weighted Average
	1.460		90.12% Pervious Area
	0.160		9.88% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.4	602	0.1576	2.30		Lag/CN Method,
4.4	602	Total, Increased to minimum Tc = 5.0 min			

Subcatchment 3A: Watershed 3A



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Summary for Subcatchment 3B: Watershed 3B

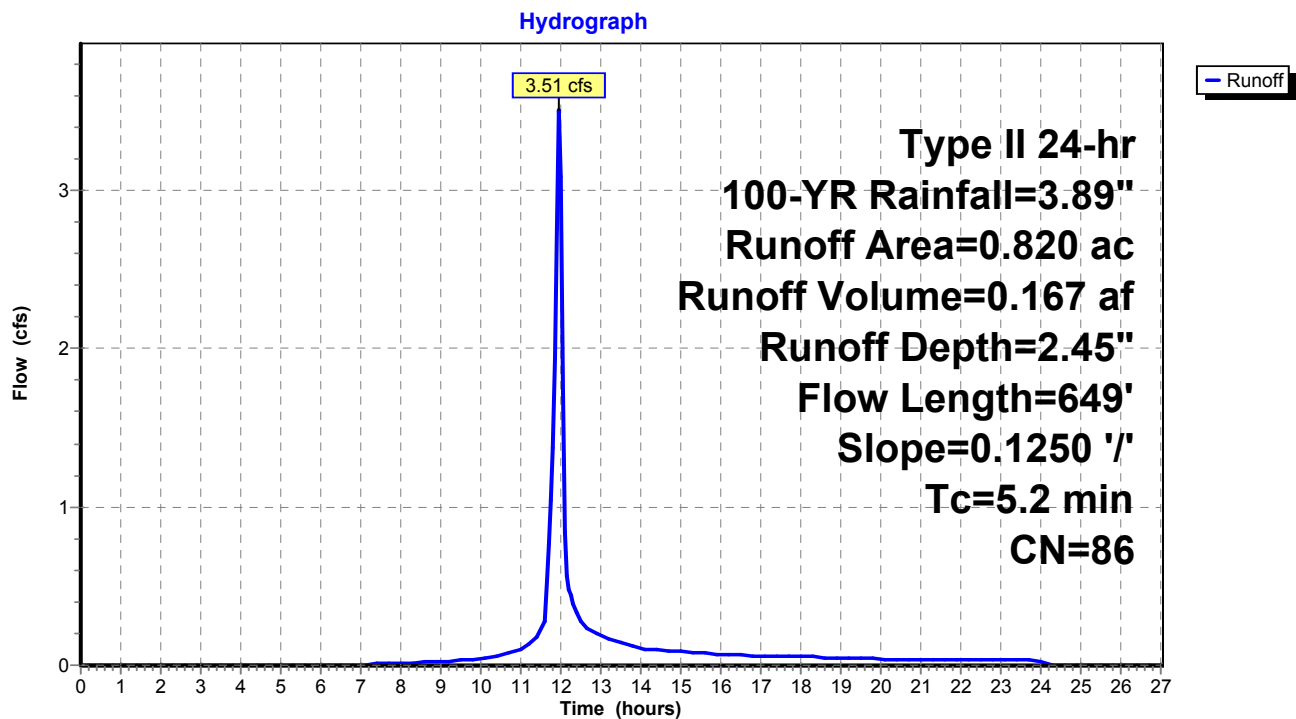
Runoff = 3.51 cfs @ 11.96 hrs, Volume= 0.167 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.080	98	10% Impervious
0.740	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
0.820	86	Weighted Average
0.740		90.24% Pervious Area
0.080		9.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.2	649	0.1250	2.08		Lag/CN Method,

Subcatchment 3B: Watershed 3B



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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 3C: Watershed 3C

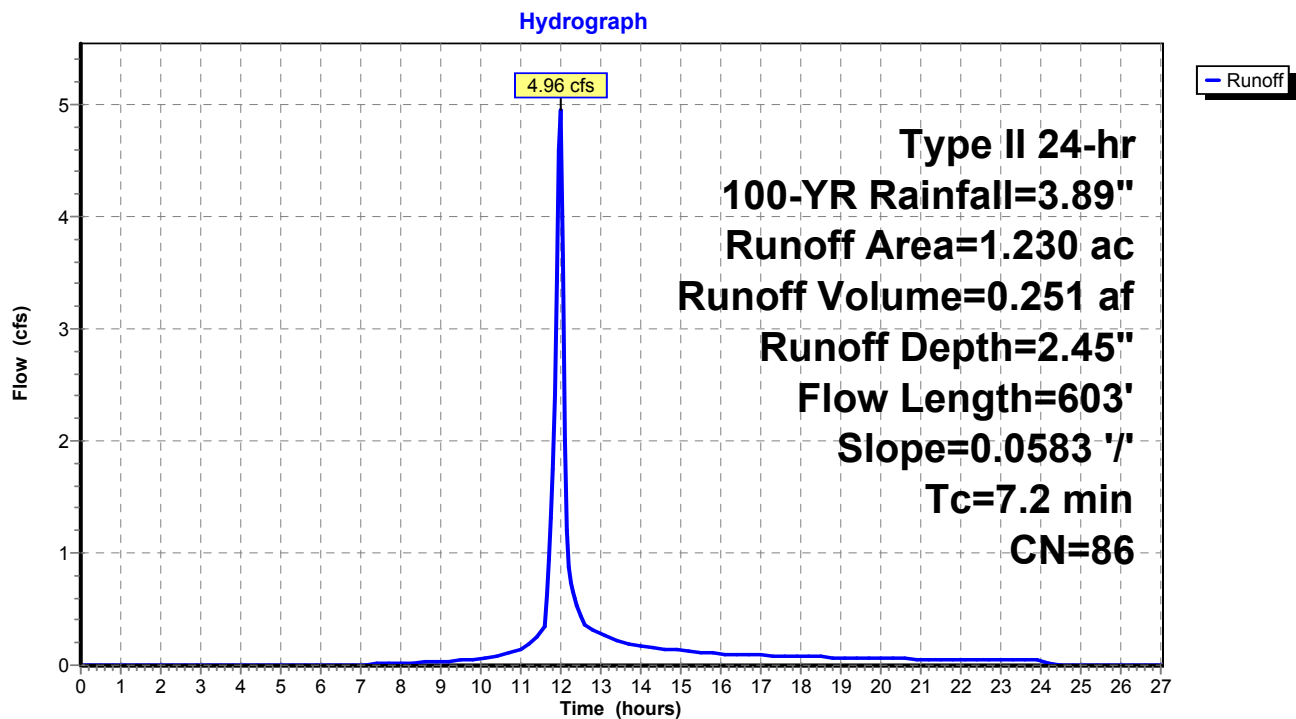
Runoff = 4.96 cfs @ 11.98 hrs, Volume= 0.251 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.120	98	10% Impervious
1.110	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
1.230	86	Weighted Average
1.110		90.24% Pervious Area
0.120		9.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.2	603	0.0583	1.40		Lag/CN Method,

Subcatchment 3C: Watershed 3C



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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 4: Watershed 4

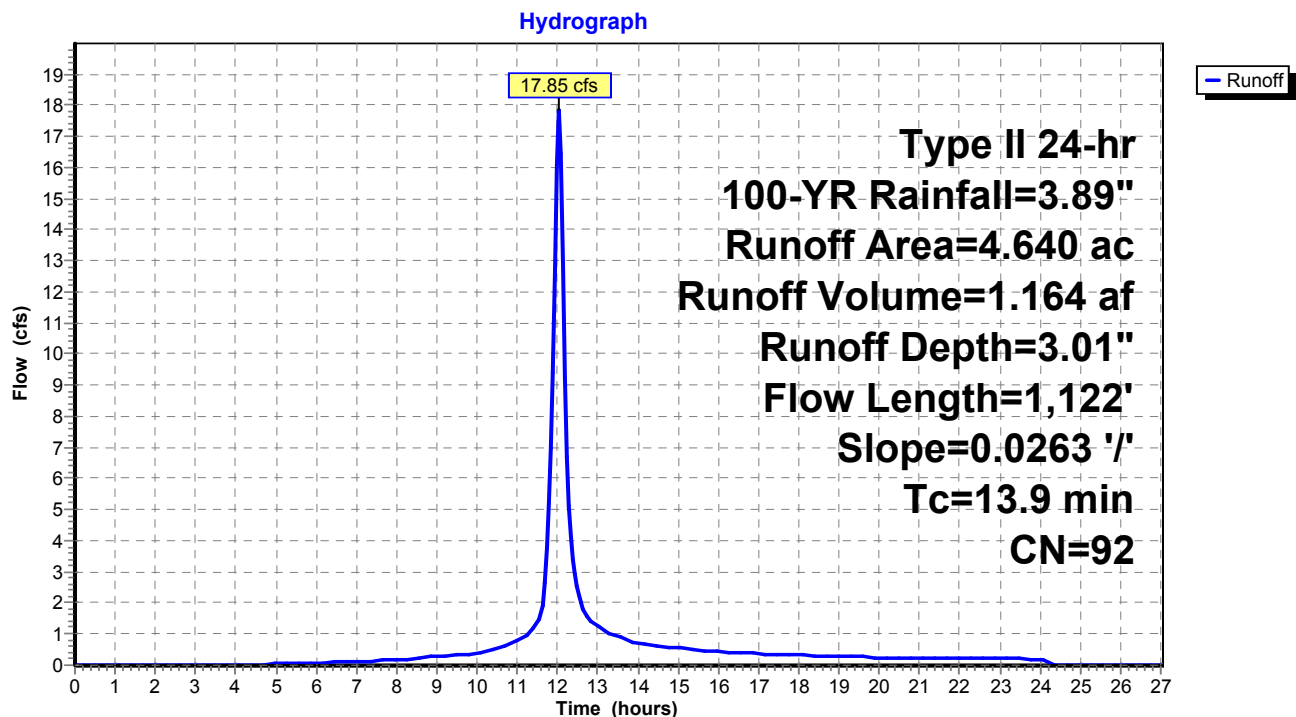
Runoff = 17.85 cfs @ 12.05 hrs, Volume= 1.164 af, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.460	98	10% Impervious
0.000	85	Desert shrub range, Poor, HSG C
4.180	91	Newly graded area, HSG C
4.640	92	Weighted Average
4.180		90.09% Pervious Area
0.460		9.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.9	1,122	0.0263	1.35		Lag/CN Method,

Subcatchment 4: Watershed 4



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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 5: Watershed 5

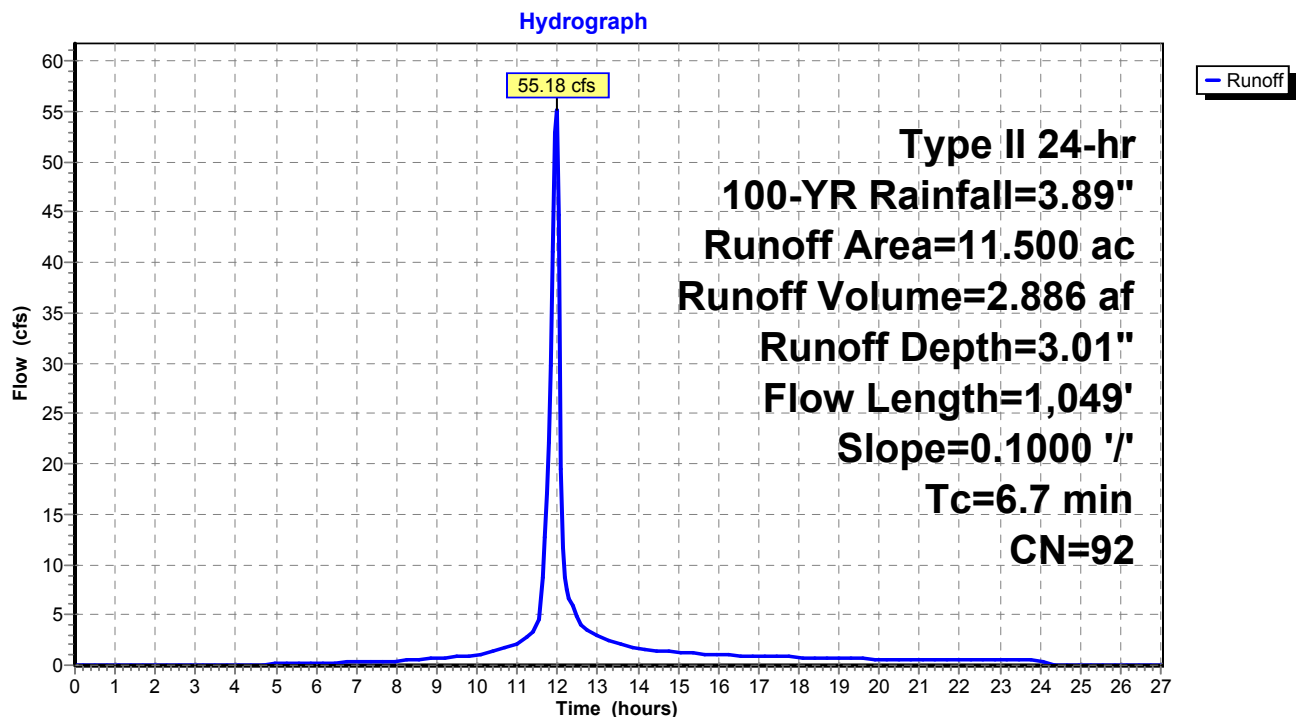
Runoff = 55.18 cfs @ 11.98 hrs, Volume= 2.886 af, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 1.150	98	10% Impervious
0.000	85	Desert shrub range, Poor, HSG C
10.350	91	Newly graded area, HSG C
11.500	92	Weighted Average
10.350		90.00% Pervious Area
1.150		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.7	1,049	0.1000	2.60		Lag/CN Method,

Subcatchment 5: Watershed 5



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Summary for Subcatchment 6: Watershed 6

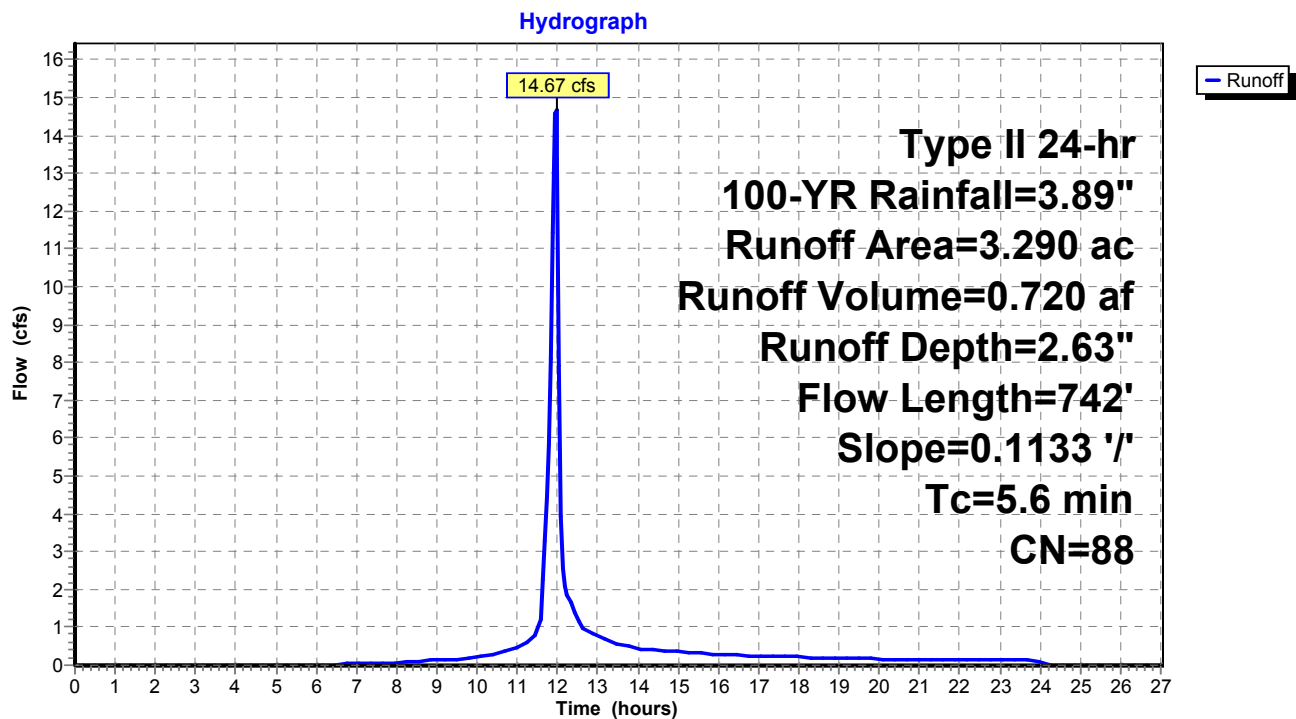
Runoff = 14.67 cfs @ 11.96 hrs, Volume= 0.720 af, Depth= 2.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

	Area (ac)	CN	Description
*	0.330	98	10% Impervious
	1.970	85	Desert shrub range, Poor, HSG C
	0.990	91	Newly graded area, HSG C
	3.290	88	Weighted Average
	2.960		89.97% Pervious Area
	0.330		10.03% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	742	0.1133	2.19		Lag/CN Method,

Subcatchment 6: Watershed 6



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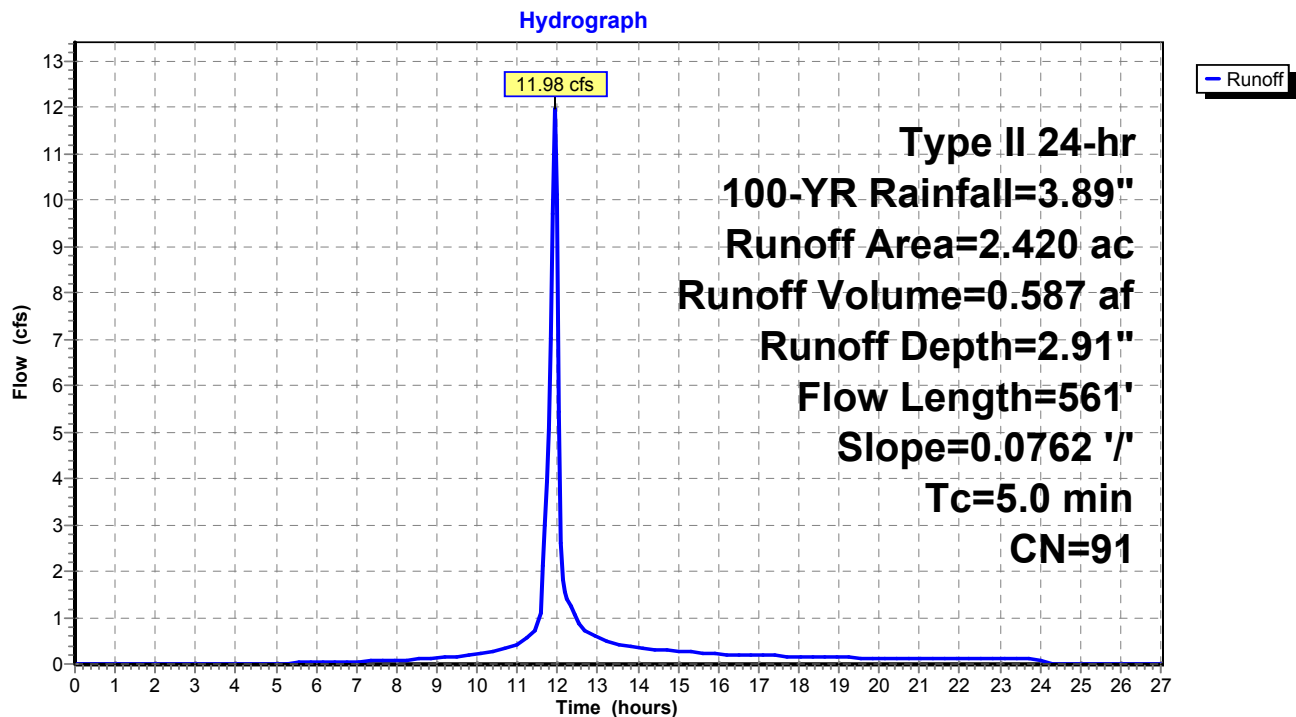
Summary for Subcatchment 7: Watershed 7

Runoff = 11.98 cfs @ 11.95 hrs, Volume= 0.587 af, Depth= 2.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.240	98	10% Impervious
0.480	85	Desert shrub range, Poor, HSG C
1.700	91	Newly graded area, HSG C
2.420	91	Weighted Average
2.180		90.08% Pervious Area
0.240		9.92% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	561	0.0762	1.92		Lag/CN Method,
4.9	561	Total, Increased to minimum Tc = 5.0 min			

Subcatchment 7: Watershed 7

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Summary for Subcatchment 8A: Watershed 8A

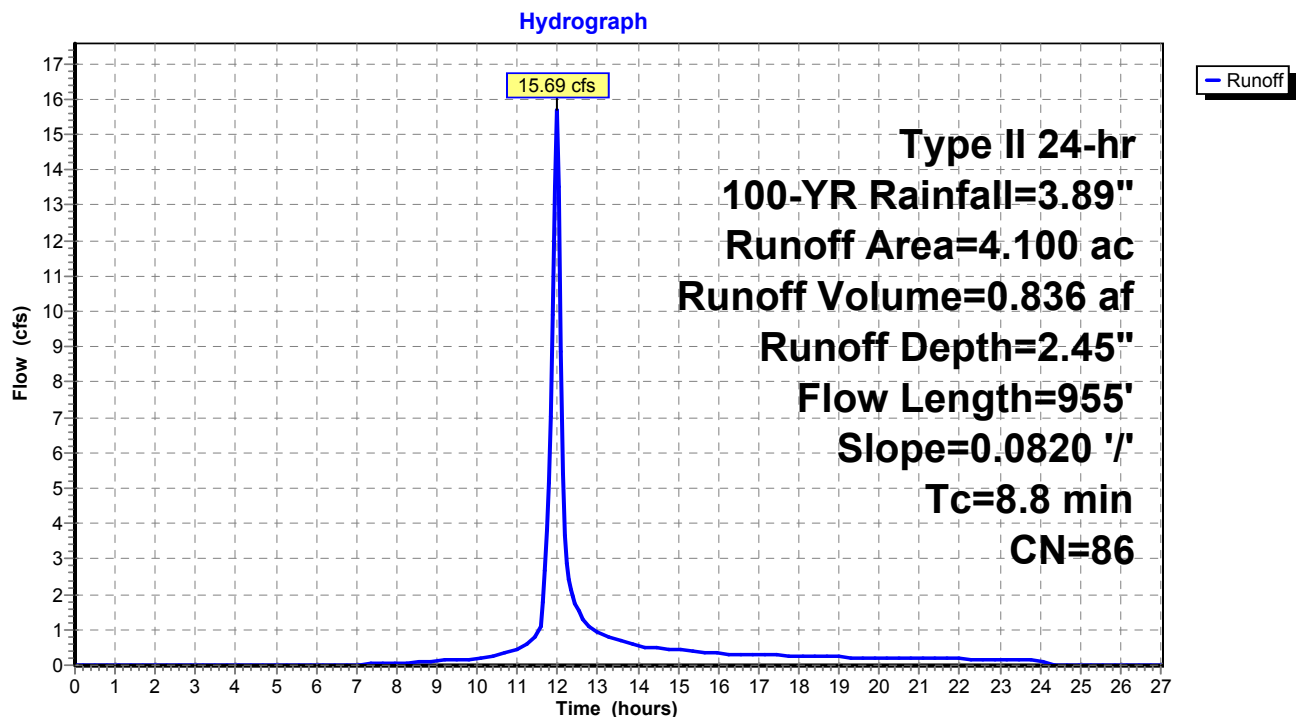
Runoff = 15.69 cfs @ 12.00 hrs, Volume= 0.836 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.410	98	10% Impervious
3.690	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
4.100	86	Weighted Average
3.690		90.00% Pervious Area
0.410		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	955	0.0820	1.82		Lag/CN Method,

Subcatchment 8A: Watershed 8A



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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 8B: Watershed 8B

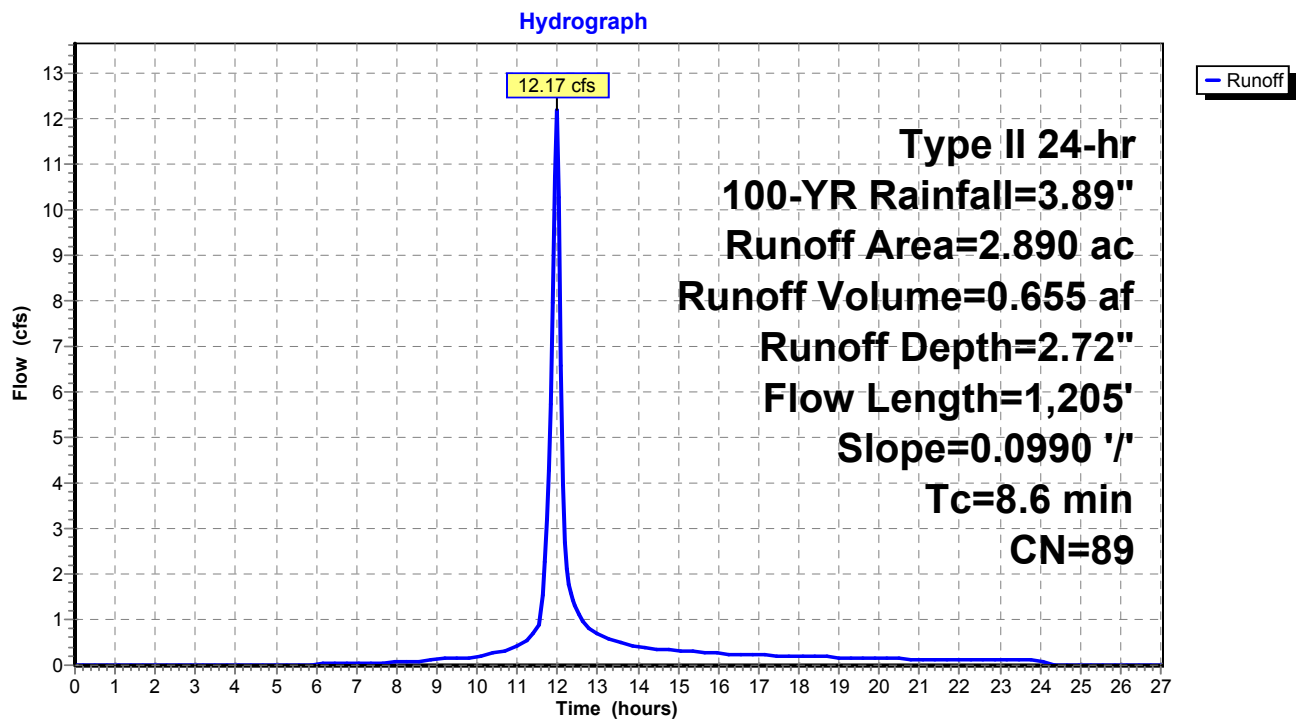
Runoff = 12.17 cfs @ 12.00 hrs, Volume= 0.655 af, Depth= 2.72"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.290	98	10% Impervious
1.150	85	Desert shrub range, Poor, HSG C
1.450	91	Newly graded area, HSG C
2.890	89	Weighted Average
2.600		89.97% Pervious Area
0.290		10.03% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.6	1,205	0.0990	2.34		Lag/CN Method,

Subcatchment 8B: Watershed 8B



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Summary for Subcatchment 9: Watershed 9

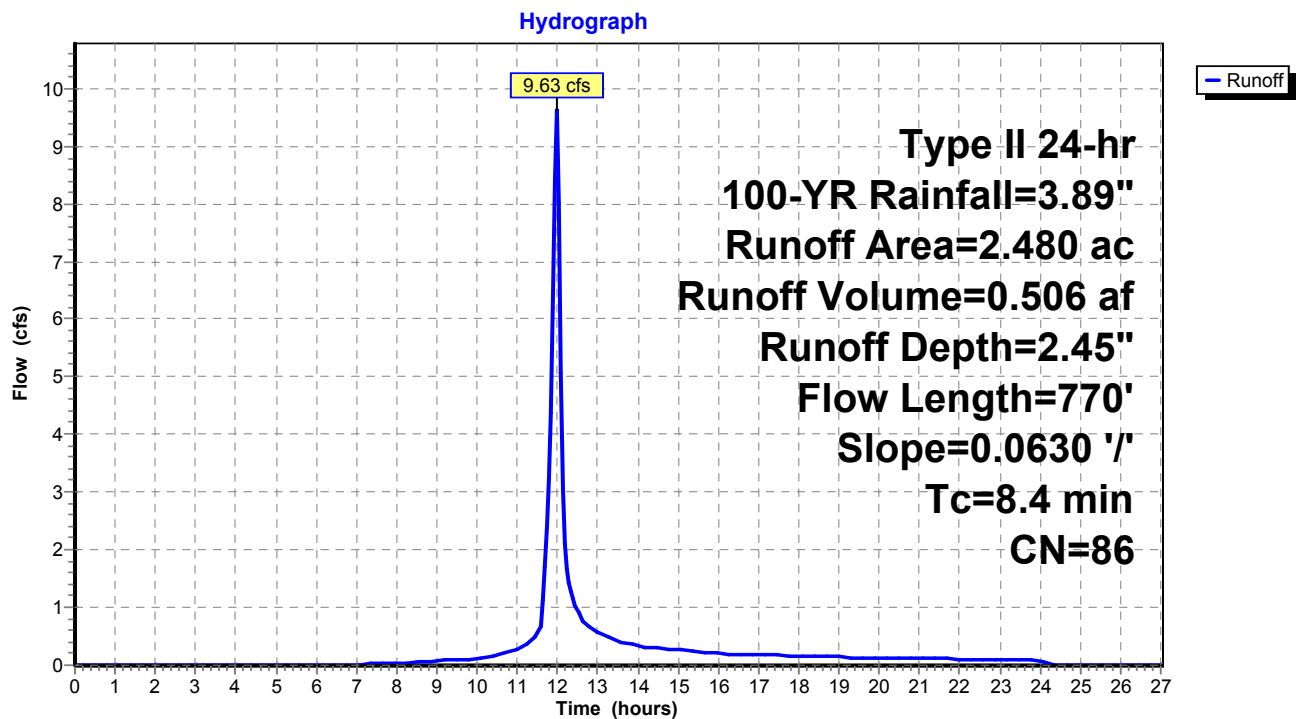
Runoff = 9.63 cfs @ 12.00 hrs, Volume= 0.506 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.250	98	10% Impervious
2.230	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
2.480	86	Weighted Average
2.230		89.92% Pervious Area
0.250		10.08% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.4	770	0.0630	1.53		Lag/CN Method,

Subcatchment 9: Watershed 9



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Summary for Subcatchment 10: Watershed 10

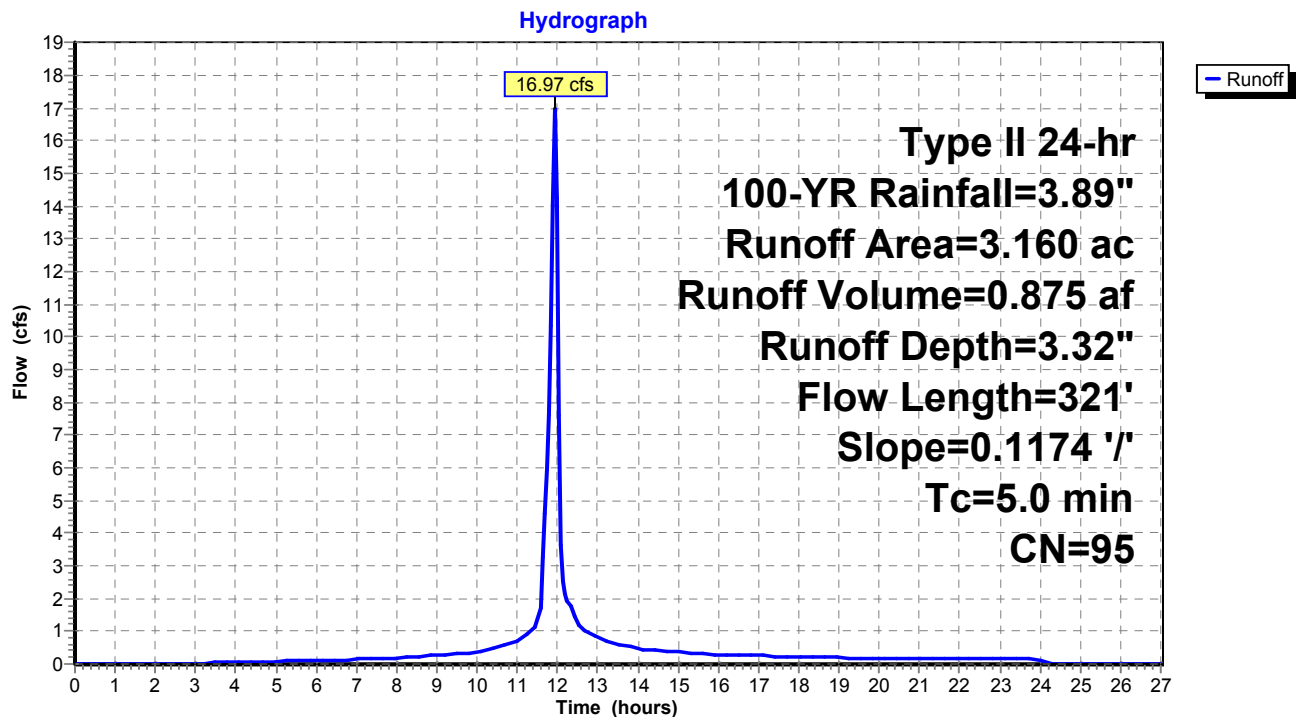
Runoff = 16.97 cfs @ 11.95 hrs, Volume= 0.875 af, Depth= 3.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

	Area (ac)	CN	Description
*	1.580	98	10% Impervious
	0.000	85	Desert shrub range, Poor, HSG C
	1.580	91	Newly graded area, HSG C
	3.160	95	Weighted Average
	1.580		50.00% Pervious Area
	1.580		50.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.1	321	0.1174	2.56		Lag/CN Method,
2.1	321	Total, Increased to minimum Tc = 5.0 min			

Subcatchment 10: Watershed 10



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Summary for Subcatchment 11: Watershed 11

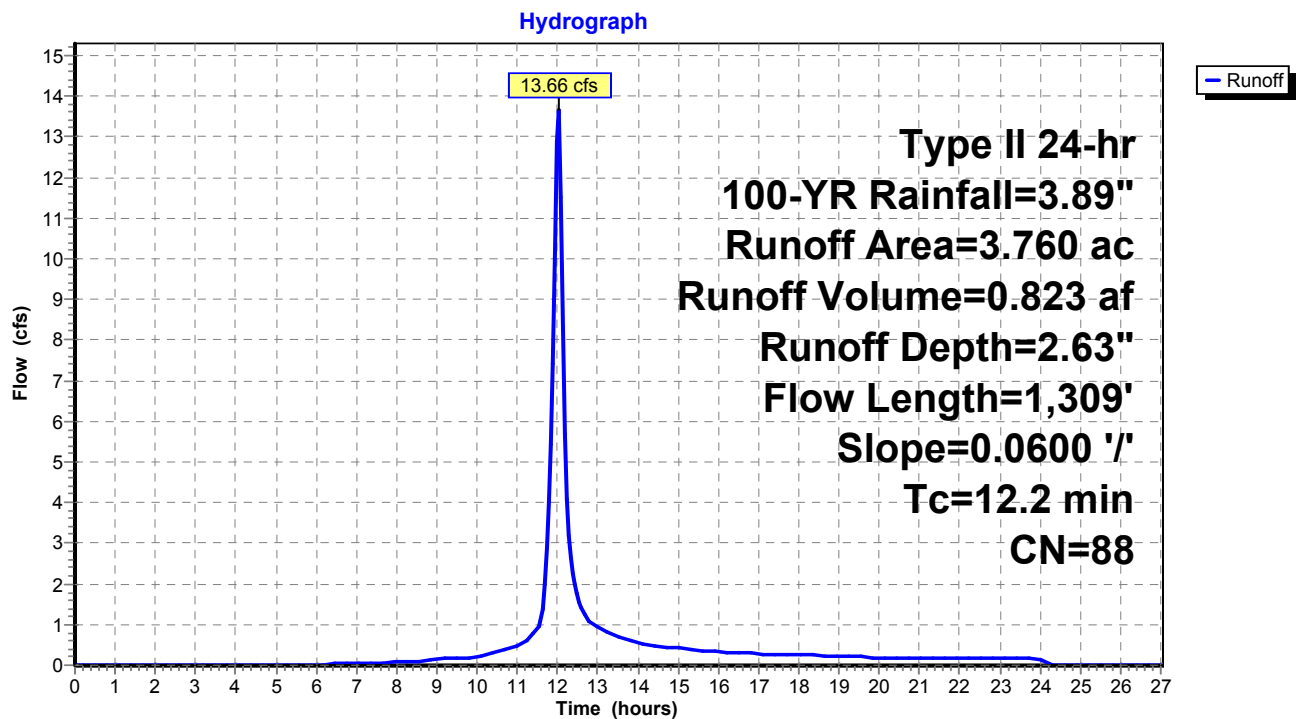
Runoff = 13.66 cfs @ 12.04 hrs, Volume= 0.823 af, Depth= 2.63"

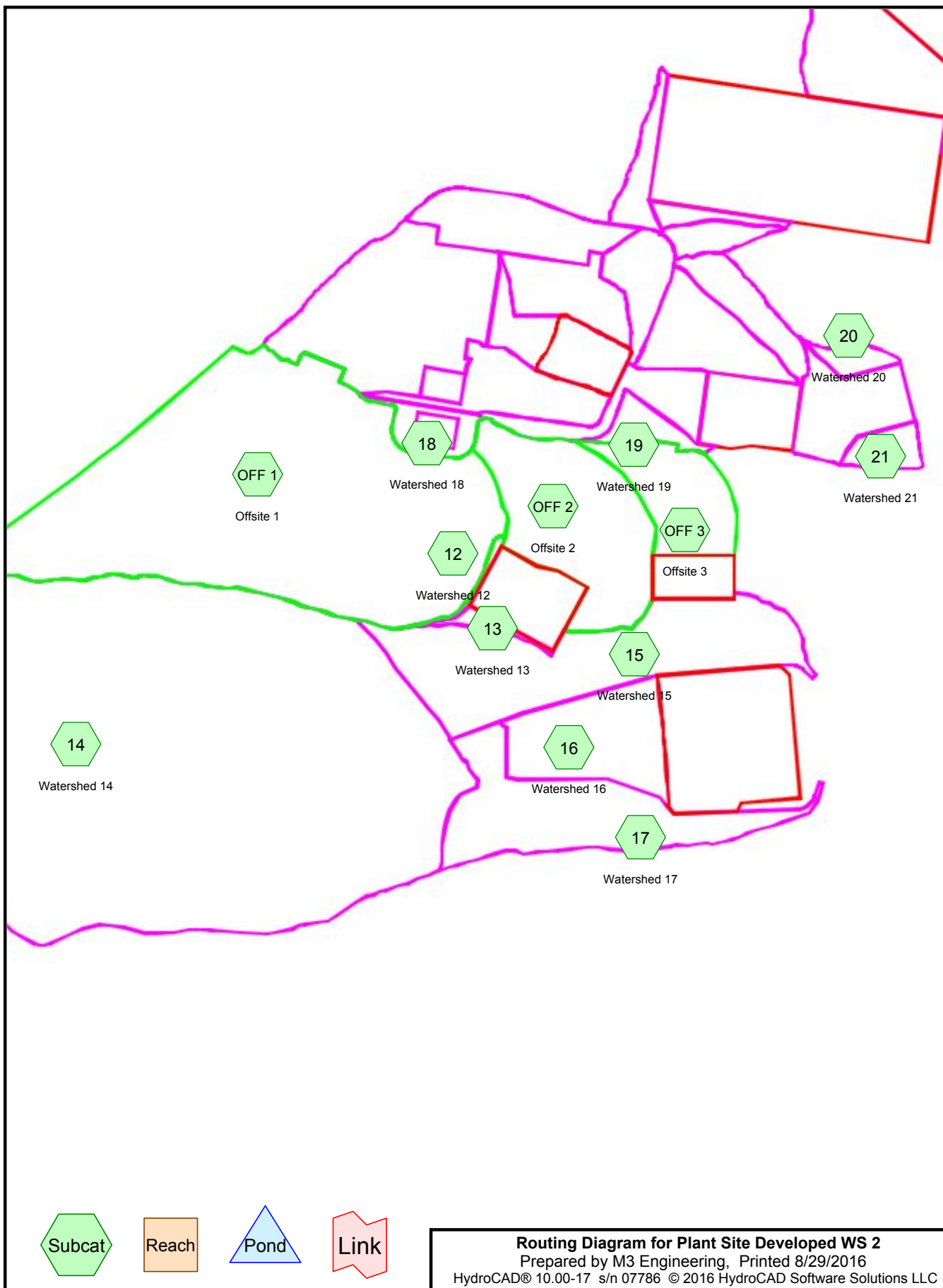
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.380	98	10% Impervious
2.250	85	Desert shrub range, Poor, HSG C
1.130	91	Newly graded area, HSG C
3.760	88	Weighted Average
3.380		89.89% Pervious Area
0.380		10.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.2	1,309	0.0600	1.78		Lag/CN Method,

Subcatchment 11: Watershed 11





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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
19.100	98	10% Impervious (12, 13, 14, 15, 16, 17, 18, 19, 20, 21, OFF 1, OFF 2, OFF 3)
163.760	85	Desert shrub range, Poor, HSG C (12, 13, 14, 15, 17, 19, 20, 21, OFF 1, OFF 2, OFF 3)
8.190	91	Newly graded area, HSG C (12, 13, 15, 16, 17, 18)
191.050	87	TOTAL AREA

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Type II 24-hr 10-YR Rainfall=2.68"

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Time span=0.00-27.00 hrs, dt=0.05 hrs, 541 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment12: Watershed 12 Runoff Area=0.260 ac 11.54% Impervious Runoff Depth=1.69"
Tc=5.0 min CN=90 Runoff=0.78 cfs 0.037 af

Subcatchment13: Watershed 13 Runoff Area=0.480 ac 10.42% Impervious Runoff Depth=1.46"
Tc=5.0 min CN=87 Runoff=1.26 cfs 0.059 af

Subcatchment14: Watershed 14 Runoff Area=99.740 ac 10.00% Impervious Runoff Depth=1.39"
Flow Length=3,943' Slope=0.0514 '/' Tc=34.4 min CN=86 Runoff=109.23 cfs 11.570 af

Subcatchment15: Watershed 15 Runoff Area=13.950 ac 10.04% Impervious Runoff Depth=1.46"
Flow Length=2,332' Slope=0.0509 '/' Tc=21.9 min CN=87 Runoff=21.46 cfs 1.701 af

Subcatchment16: Watershed 16 Runoff Area=6.330 ac 9.95% Impervious Runoff Depth=1.86"
Flow Length=573' Slope=0.0200 '/' Tc=9.3 min CN=92 Runoff=17.82 cfs 0.981 af

Subcatchment17: Watershed 17 Runoff Area=9.570 ac 10.03% Impervious Runoff Depth=1.46"
Flow Length=2,086' Slope=0.1001 '/' Tc=14.3 min CN=87 Runoff=18.41 cfs 1.167 af

Subcatchment18: Watershed 18 Runoff Area=1.250 ac 9.60% Impervious Runoff Depth=1.86"
Tc=5.0 min CN=92 Runoff=4.03 cfs 0.194 af

Subcatchment19: Watershed 19 Runoff Area=1.310 ac 9.92% Impervious Runoff Depth=1.39"
Tc=5.0 min CN=86 Runoff=3.27 cfs 0.152 af

Subcatchment20: Watershed 20 Runoff Area=1.070 ac 10.28% Impervious Runoff Depth=1.39"
Flow Length=523' Slope=0.0758 '/' Tc=5.6 min CN=86 Runoff=2.60 cfs 0.124 af

Subcatchment21: Watershed 21 Runoff Area=1.900 ac 10.00% Impervious Runoff Depth=1.39"
Flow Length=620' Slope=0.0715 '/' Tc=6.6 min CN=86 Runoff=4.51 cfs 0.220 af

SubcatchmentOFF 1: Offsite 1 Runoff Area=40.040 ac 9.99% Impervious Runoff Depth=1.39"
Flow Length=2,598' Slope=0.0866 '/' Tc=19.0 min CN=86 Runoff=63.48 cfs 4.645 af

SubcatchmentOFF 2: Offsite 2 Runoff Area=10.400 ac 10.00% Impervious Runoff Depth=1.39"
Flow Length=1,075' Slope=0.0906 '/' Tc=9.2 min CN=86 Runoff=22.61 cfs 1.206 af

SubcatchmentOFF 3: Offsite 3 Runoff Area=4.750 ac 9.89% Impervious Runoff Depth=1.39"
Flow Length=827' Slope=0.0507 '/' Tc=9.9 min CN=86 Runoff=10.05 cfs 0.551 af

Total Runoff Area = 191.050 ac Runoff Volume = 22.606 af Average Runoff Depth = 1.42"
90.00% Pervious = 171.950 ac 10.00% Impervious = 19.100 ac

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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 12: Watershed 12

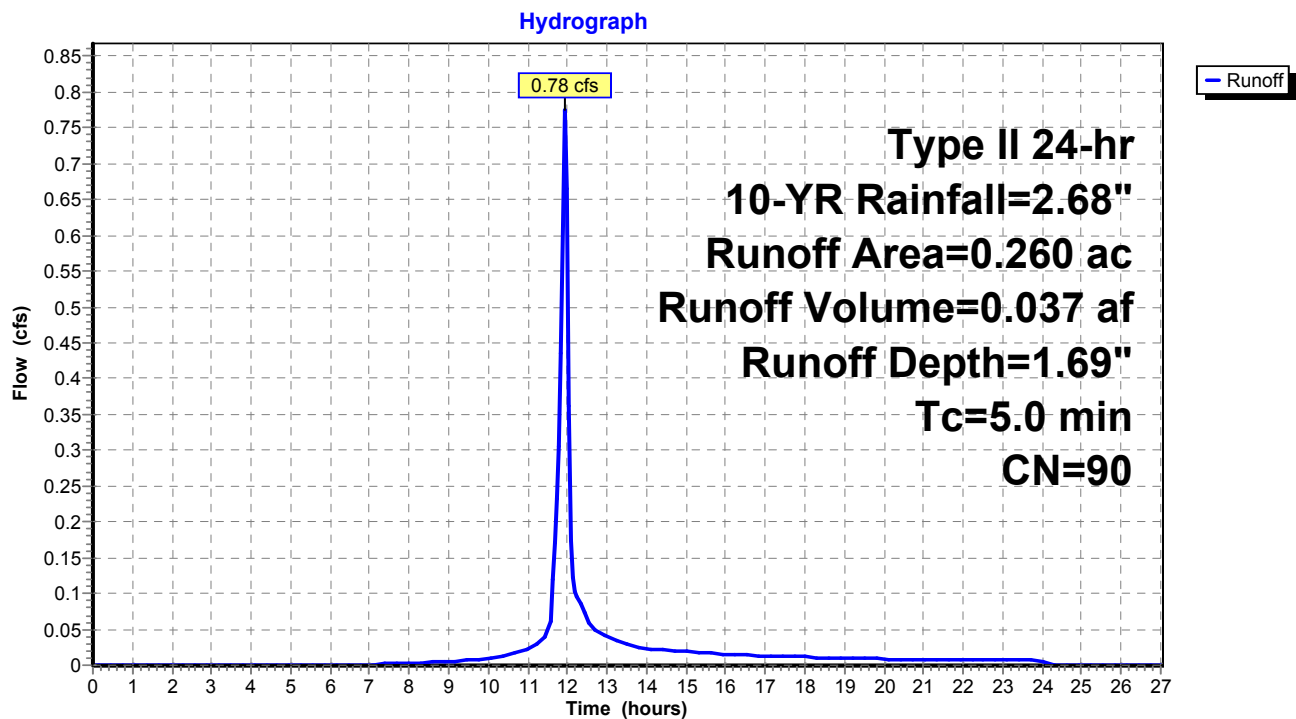
Runoff = 0.78 cfs @ 11.95 hrs, Volume= 0.037 af, Depth= 1.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.030	98	10% Impervious
0.100	85	Desert shrub range, Poor, HSG C
0.130	91	Newly graded area, HSG C
0.260	90	Weighted Average
0.230		88.46% Pervious Area
0.030		11.54% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 12: Watershed 12



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 13: Watershed 13

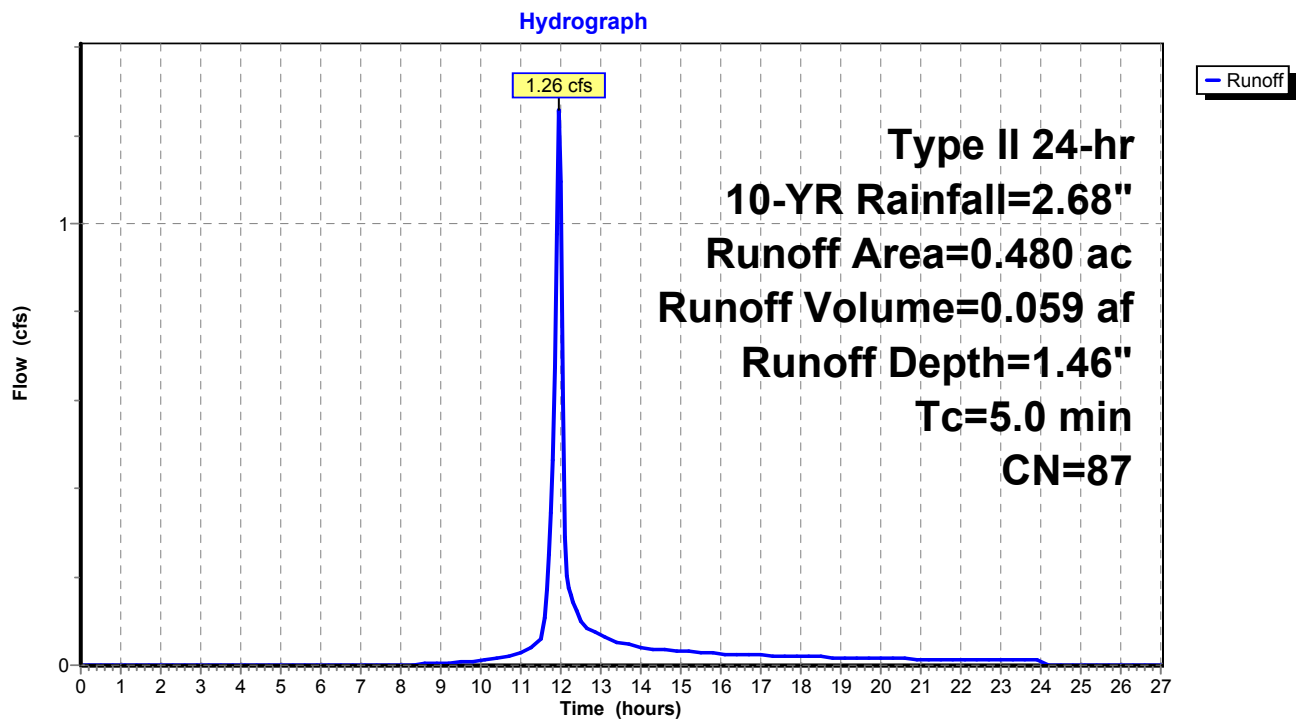
Runoff = 1.26 cfs @ 11.96 hrs, Volume= 0.059 af, Depth= 1.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.050	98	10% Impervious
0.380	85	Desert shrub range, Poor, HSG C
0.050	91	Newly graded area, HSG C
0.480	87	Weighted Average
0.430		89.58% Pervious Area
0.050		10.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 13: Watershed 13



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 14: Watershed 14

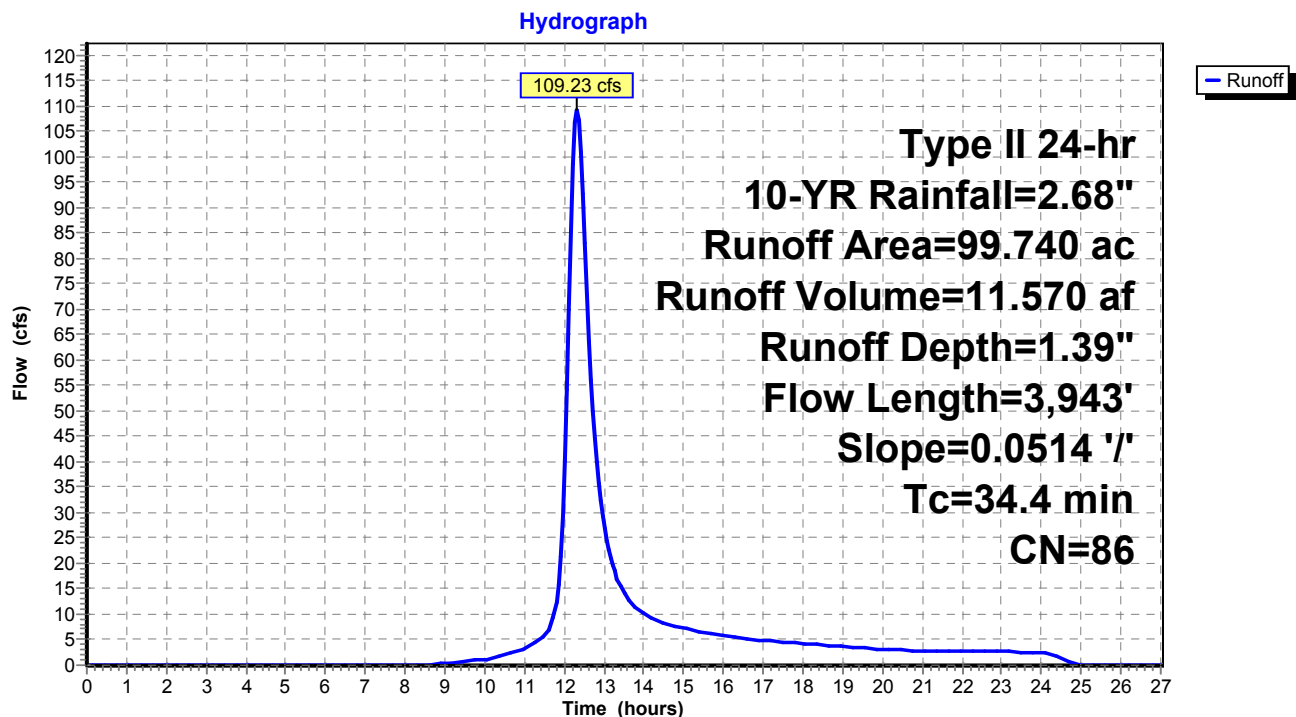
Runoff = 109.23 cfs @ 12.30 hrs, Volume= 11.570 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 9.970	98	10% Impervious
89.770	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
99.740	86	Weighted Average
89.770		90.00% Pervious Area
9.970		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.4	3,943	0.0514	1.91		Lag/CN Method,

Subcatchment 14: Watershed 14



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 15: Watershed 15

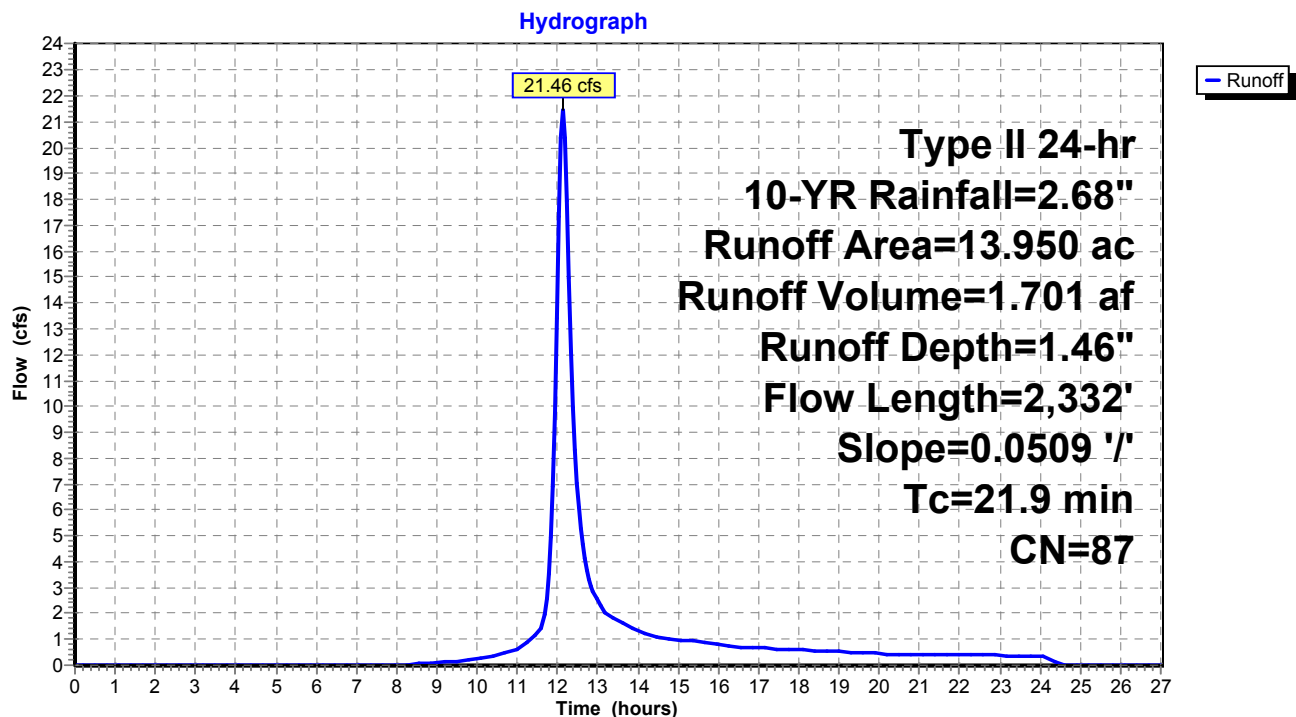
Runoff = 21.46 cfs @ 12.15 hrs, Volume= 1.701 af, Depth= 1.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 1.400	98	10% Impervious
11.850	85	Desert shrub range, Poor, HSG C
0.700	91	Newly graded area, HSG C
13.950	87	Weighted Average
12.550		89.96% Pervious Area
1.400		10.04% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.9	2,332	0.0509	1.78		Lag/CN Method,

Subcatchment 15: Watershed 15



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 16: Watershed 16

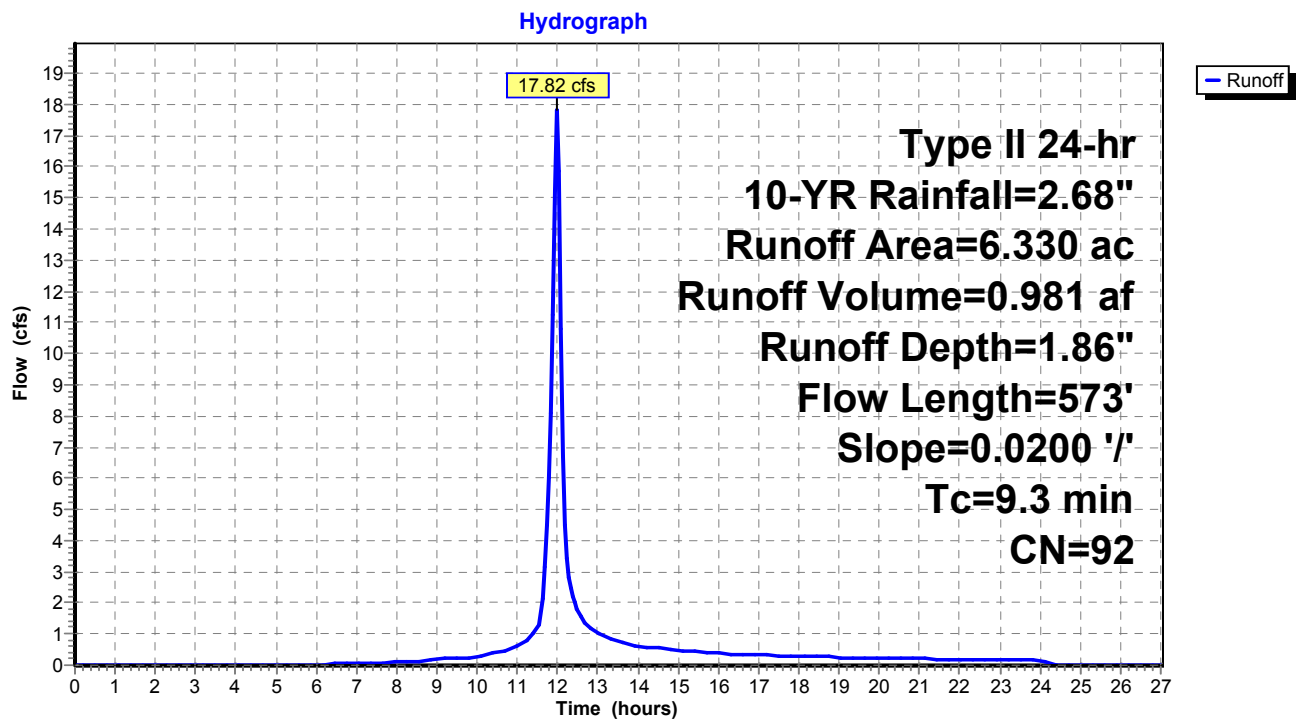
Runoff = 17.82 cfs @ 12.00 hrs, Volume= 0.981 af, Depth= 1.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.630	98	10% Impervious
0.000	85	Desert shrub range, Poor, HSG C
5.700	91	Newly graded area, HSG C
6.330	92	Weighted Average
5.700		90.05% Pervious Area
0.630		9.95% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	573	0.0200	1.03		Lag/CN Method,

Subcatchment 16: Watershed 16



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 17: Watershed 17

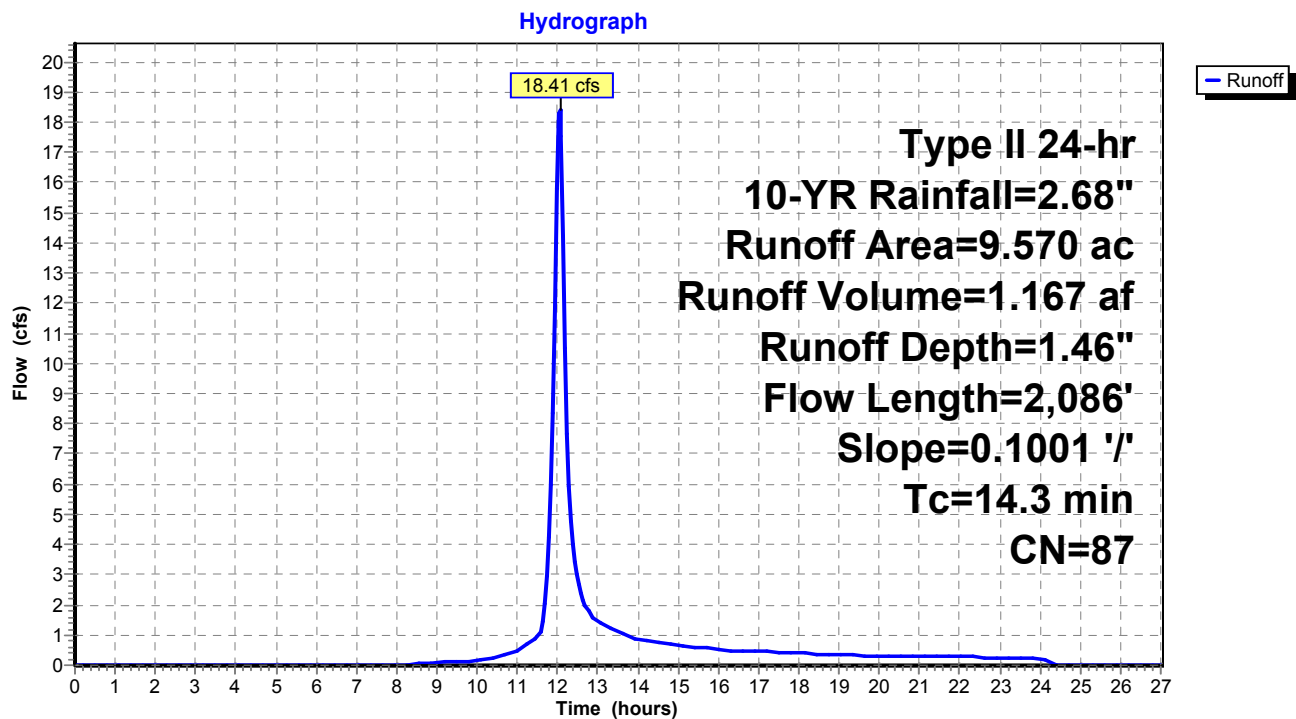
Runoff = 18.41 cfs @ 12.06 hrs, Volume= 1.167 af, Depth= 1.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.960	98	10% Impervious
8.130	85	Desert shrub range, Poor, HSG C
0.480	91	Newly graded area, HSG C
9.570	87	Weighted Average
8.610		89.97% Pervious Area
0.960		10.03% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.3	2,086	0.1001	2.44		Lag/CN Method,

Subcatchment 17: Watershed 17



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 18: Watershed 18

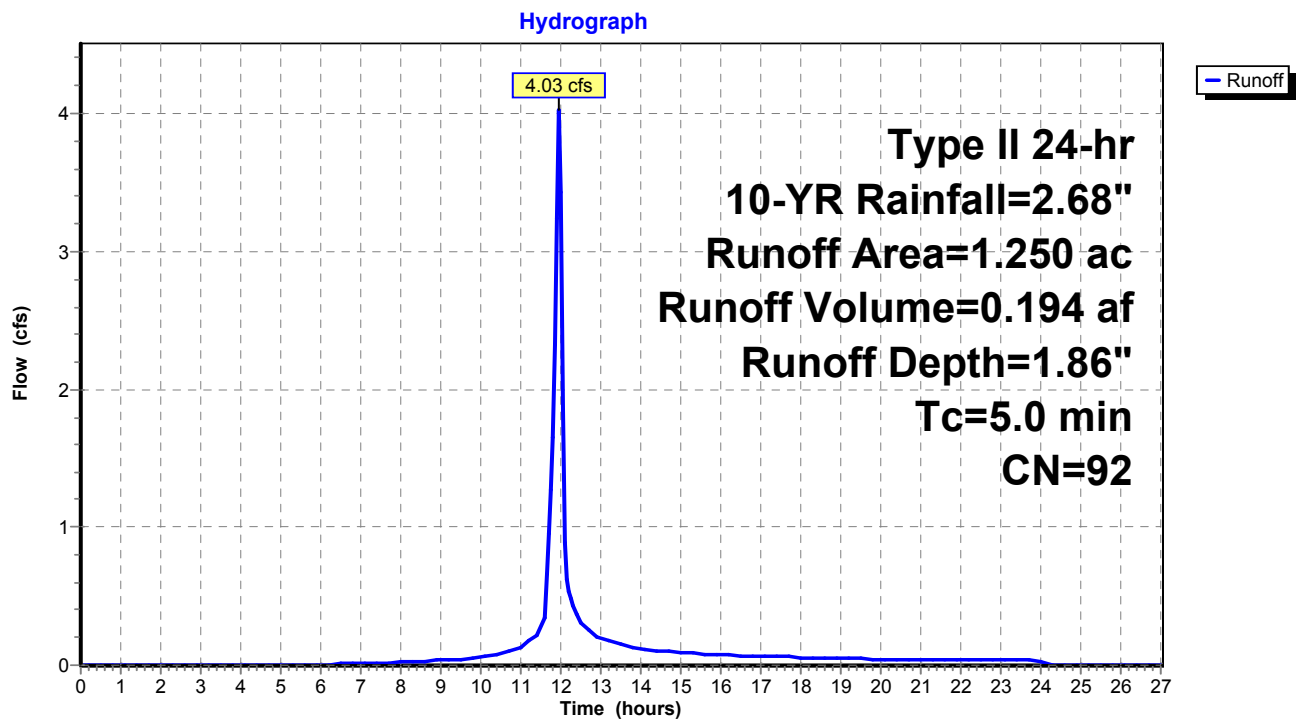
Runoff = 4.03 cfs @ 11.95 hrs, Volume= 0.194 af, Depth= 1.86"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.120	98	10% Impervious
0.000	85	Desert shrub range, Poor, HSG C
1.130	91	Newly graded area, HSG C
1.250	92	Weighted Average
1.130		90.40% Pervious Area
0.120		9.60% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 18: Watershed 18



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 19: Watershed 19

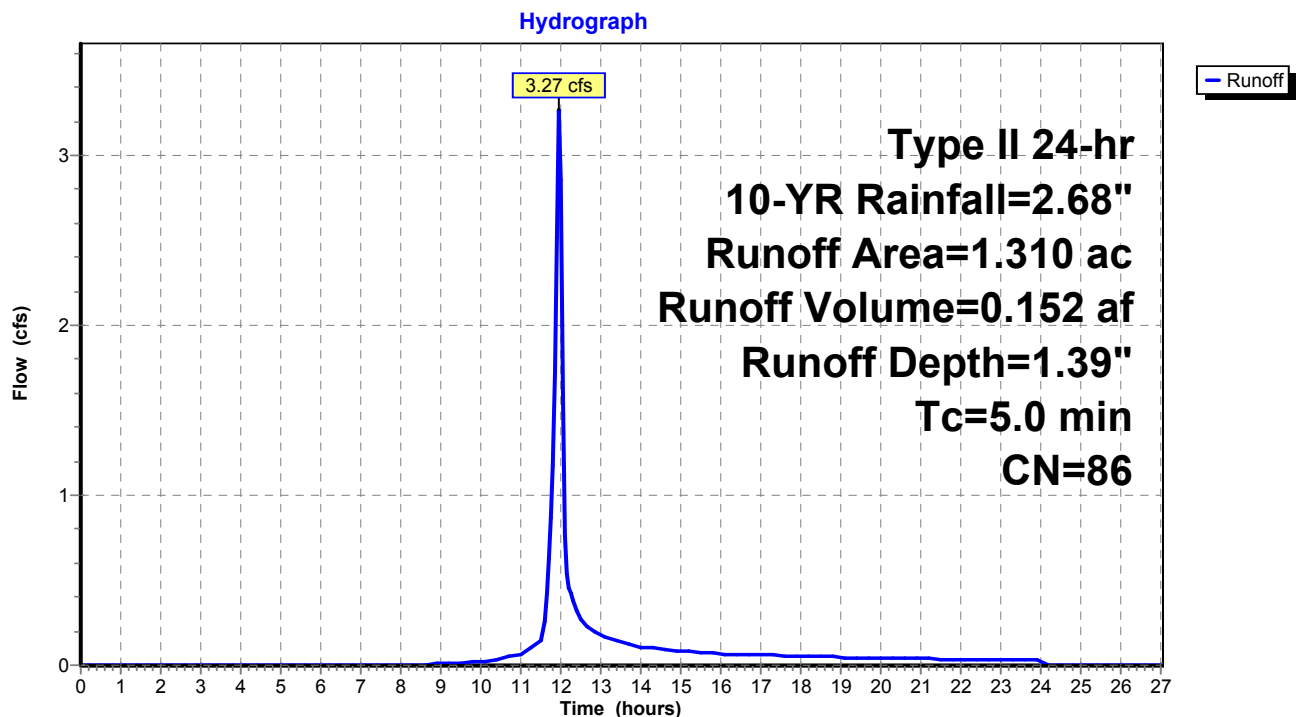
Runoff = 3.27 cfs @ 11.96 hrs, Volume= 0.152 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.130	98	10% Impervious
1.180	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
1.310	86	Weighted Average
1.180		90.08% Pervious Area
0.130		9.92% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 19: Watershed 19



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 20: Watershed 20

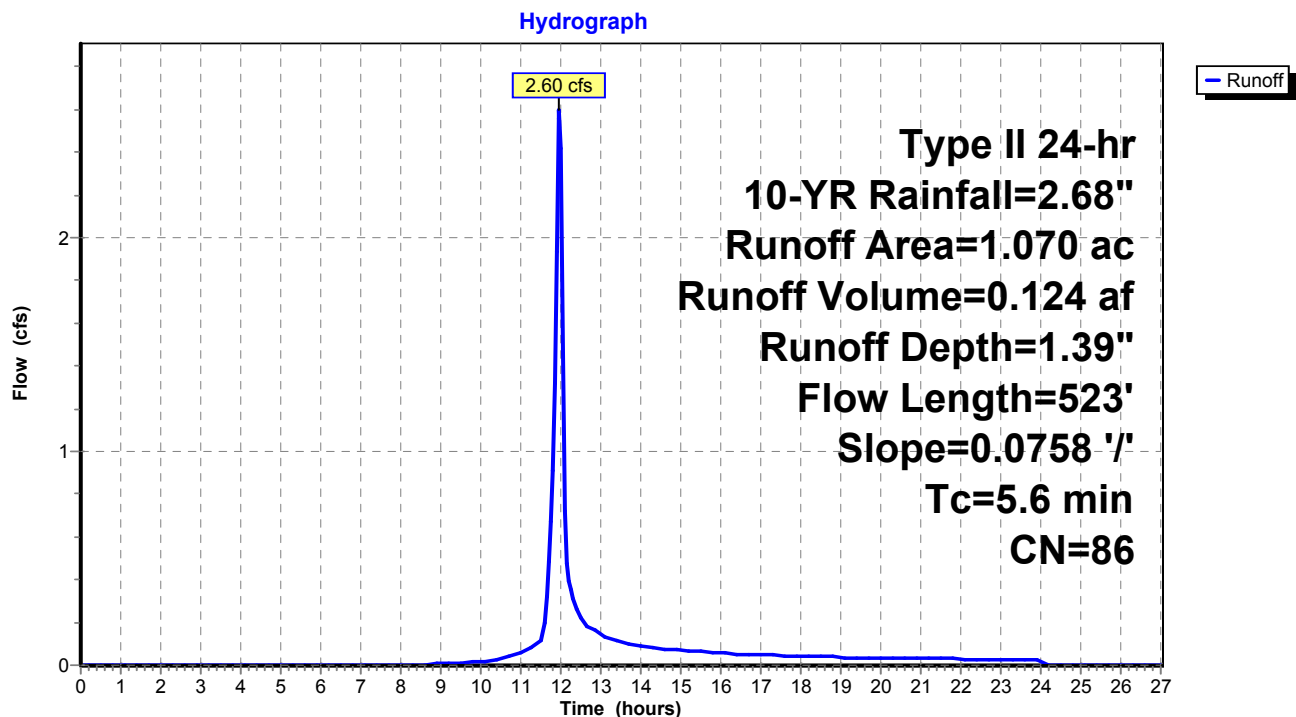
Runoff = 2.60 cfs @ 11.97 hrs, Volume= 0.124 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.110	98	10% Impervious
0.960	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
1.070	86	Weighted Average
0.960		89.72% Pervious Area
0.110		10.28% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	523	0.0758	1.55		Lag/CN Method,

Subcatchment 20: Watershed 20



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment 21: Watershed 21

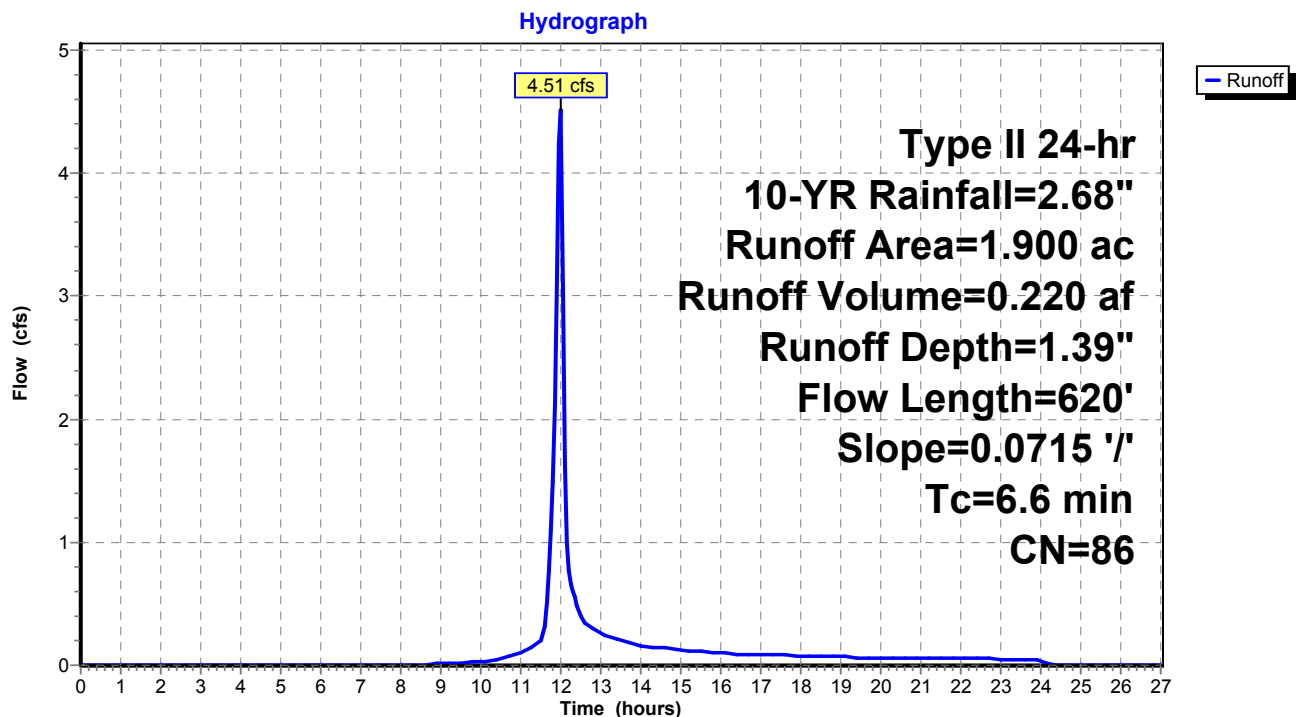
Runoff = 4.51 cfs @ 11.98 hrs, Volume= 0.220 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

	Area (ac)	CN	Description
*	0.190	98	10% Impervious
	1.710	85	Desert shrub range, Poor, HSG C
	0.000	91	Newly graded area, HSG C
	1.900	86	Weighted Average
	1.710		90.00% Pervious Area
	0.190		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	620	0.0715	1.56		Lag/CN Method,

Subcatchment 21: Watershed 21



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment OFF 1: Offsite 1

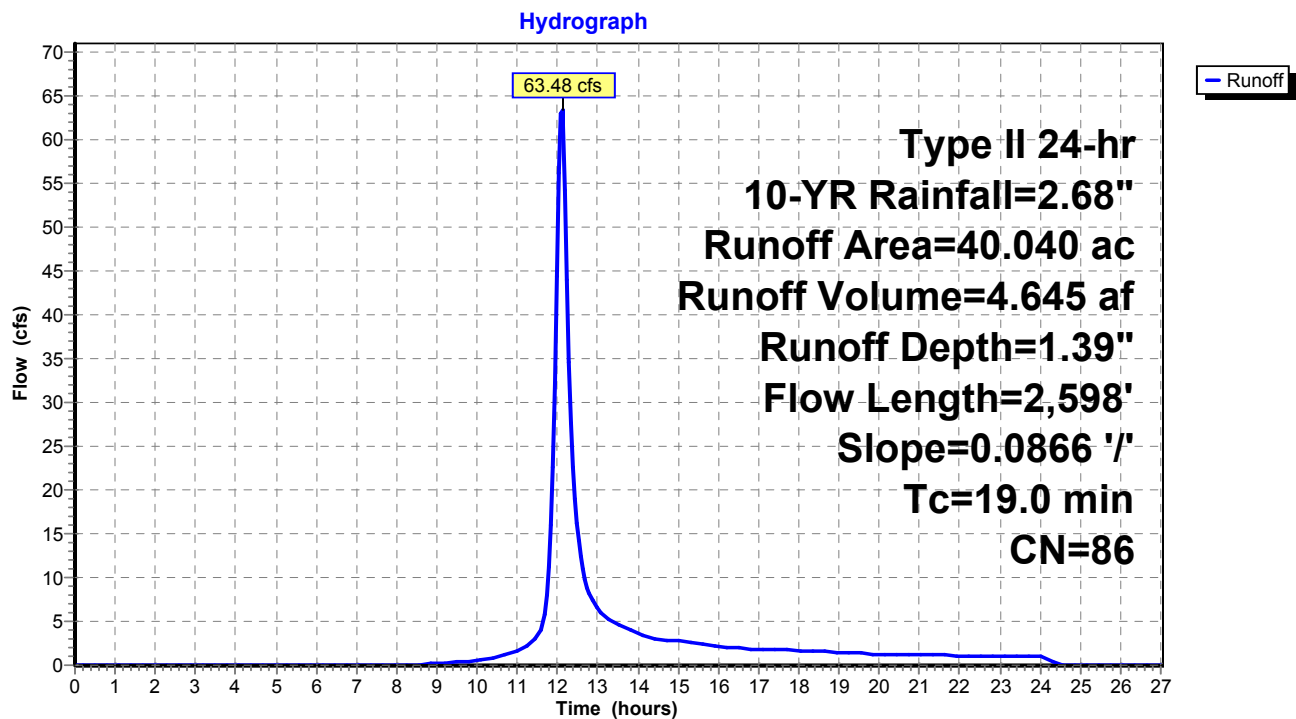
Runoff = 63.48 cfs @ 12.12 hrs, Volume= 4.645 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 4.000	98	10% Impervious
36.040	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
40.040	86	Weighted Average
36.040		90.01% Pervious Area
4.000		9.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.0	2,598	0.0866	2.28		Lag/CN Method,

Subcatchment OFF 1: Offsite 1



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment OFF 2: Offsite 2

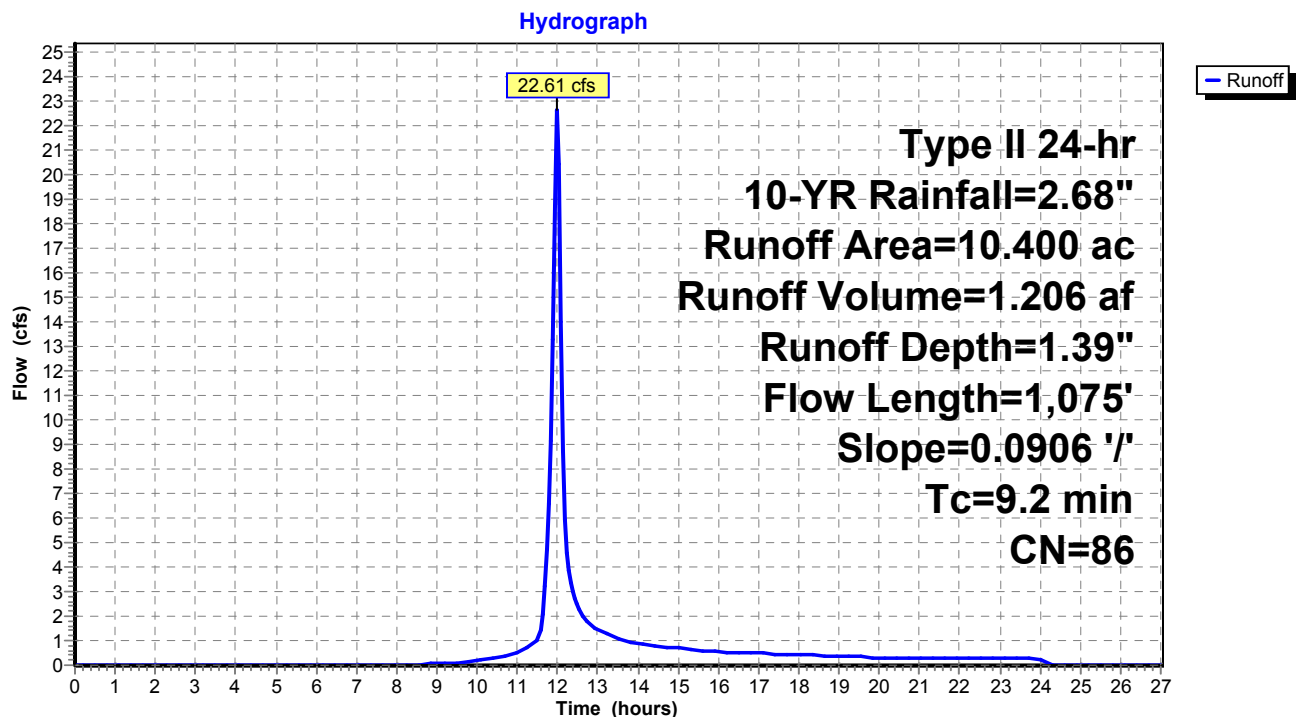
Runoff = 22.61 cfs @ 12.01 hrs, Volume= 1.206 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 1.040	98	10% Impervious
9.360	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
10.400	86	Weighted Average
9.360		90.00% Pervious Area
1.040		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.2	1,075	0.0906	1.96		Lag/CN Method,

Subcatchment OFF 2: Offsite 2



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Type II 24-hr 10-YR Rainfall=2.68"

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Summary for Subcatchment OFF 3: Offsite 3

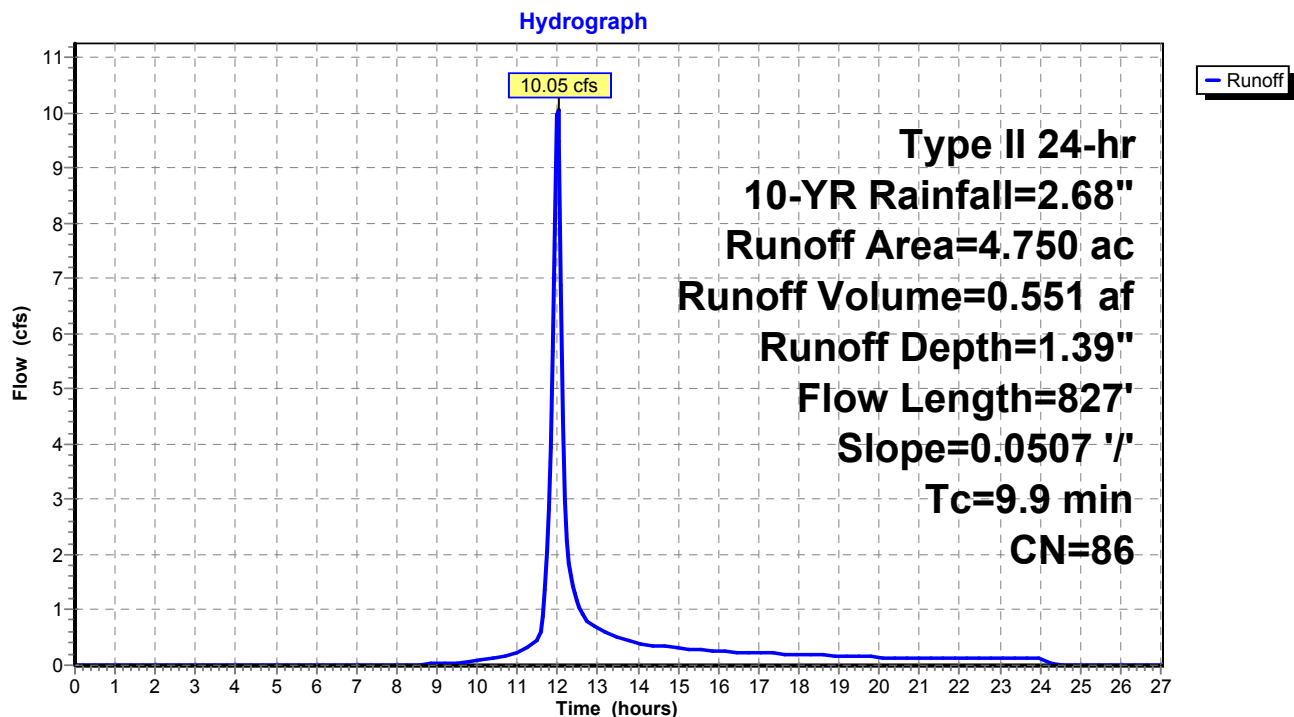
Runoff = 10.05 cfs @ 12.01 hrs, Volume= 0.551 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-YR Rainfall=2.68"

Area (ac)	CN	Description
* 0.470	98	10% Impervious
4.280	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
4.750	86	Weighted Average
4.280		90.11% Pervious Area
0.470		9.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.9	827	0.0507	1.39		Lag/CN Method,

Subcatchment OFF 3: Offsite 3



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Type II 24-hr 100-YR Rainfall=3.89"

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Time span=0.00-27.00 hrs, dt=0.05 hrs, 541 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment12: Watershed 12 Runoff Area=0.260 ac 11.54% Impervious Runoff Depth=2.82"
Tc=5.0 min CN=90 Runoff=1.26 cfs 0.061 af

Subcatchment13: Watershed 13 Runoff Area=0.480 ac 10.42% Impervious Runoff Depth=2.54"
Tc=5.0 min CN=87 Runoff=2.13 cfs 0.101 af

Subcatchment14: Watershed 14 Runoff Area=99.740 ac 10.00% Impervious Runoff Depth=2.45"
Flow Length=3,943' Slope=0.0514 '/' Tc=34.4 min CN=86 Runoff=192.93 cfs 20.338 af

Subcatchment15: Watershed 15 Runoff Area=13.950 ac 10.04% Impervious Runoff Depth=2.54"
Flow Length=2,332' Slope=0.0509 '/' Tc=21.9 min CN=87 Runoff=37.01 cfs 2.948 af

Subcatchment16: Watershed 16 Runoff Area=6.330 ac 9.95% Impervious Runoff Depth=3.01"
Flow Length=573' Slope=0.0200 '/' Tc=9.3 min CN=92 Runoff=28.10 cfs 1.589 af

Subcatchment17: Watershed 17 Runoff Area=9.570 ac 10.03% Impervious Runoff Depth=2.54"
Flow Length=2,086' Slope=0.1001 '/' Tc=14.3 min CN=87 Runoff=31.58 cfs 2.022 af

Subcatchment18: Watershed 18 Runoff Area=1.250 ac 9.60% Impervious Runoff Depth=3.01"
Tc=5.0 min CN=92 Runoff=6.33 cfs 0.314 af

Subcatchment19: Watershed 19 Runoff Area=1.310 ac 9.92% Impervious Runoff Depth=2.45"
Tc=5.0 min CN=86 Runoff=5.65 cfs 0.267 af

Subcatchment20: Watershed 20 Runoff Area=1.070 ac 10.28% Impervious Runoff Depth=2.45"
Flow Length=523' Slope=0.0758 '/' Tc=5.6 min CN=86 Runoff=4.50 cfs 0.218 af

Subcatchment21: Watershed 21 Runoff Area=1.900 ac 10.00% Impervious Runoff Depth=2.45"
Flow Length=620' Slope=0.0715 '/' Tc=6.6 min CN=86 Runoff=7.78 cfs 0.387 af

SubcatchmentOFF 1: Offsite 1 Runoff Area=40.040 ac 9.99% Impervious Runoff Depth=2.45"
Flow Length=2,598' Slope=0.0866 '/' Tc=19.0 min CN=86 Runoff=111.25 cfs 8.164 af

SubcatchmentOFF 2: Offsite 2 Runoff Area=10.400 ac 10.00% Impervious Runoff Depth=2.45"
Flow Length=1,075' Slope=0.0906 '/' Tc=9.2 min CN=86 Runoff=39.22 cfs 2.121 af

SubcatchmentOFF 3: Offsite 3 Runoff Area=4.750 ac 9.89% Impervious Runoff Depth=2.45"
Flow Length=827' Slope=0.0507 '/' Tc=9.9 min CN=86 Runoff=17.46 cfs 0.969 af

Total Runoff Area = 191.050 ac Runoff Volume = 39.499 af Average Runoff Depth = 2.48"
90.00% Pervious = 171.950 ac 10.00% Impervious = 19.100 ac

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 12: Watershed 12

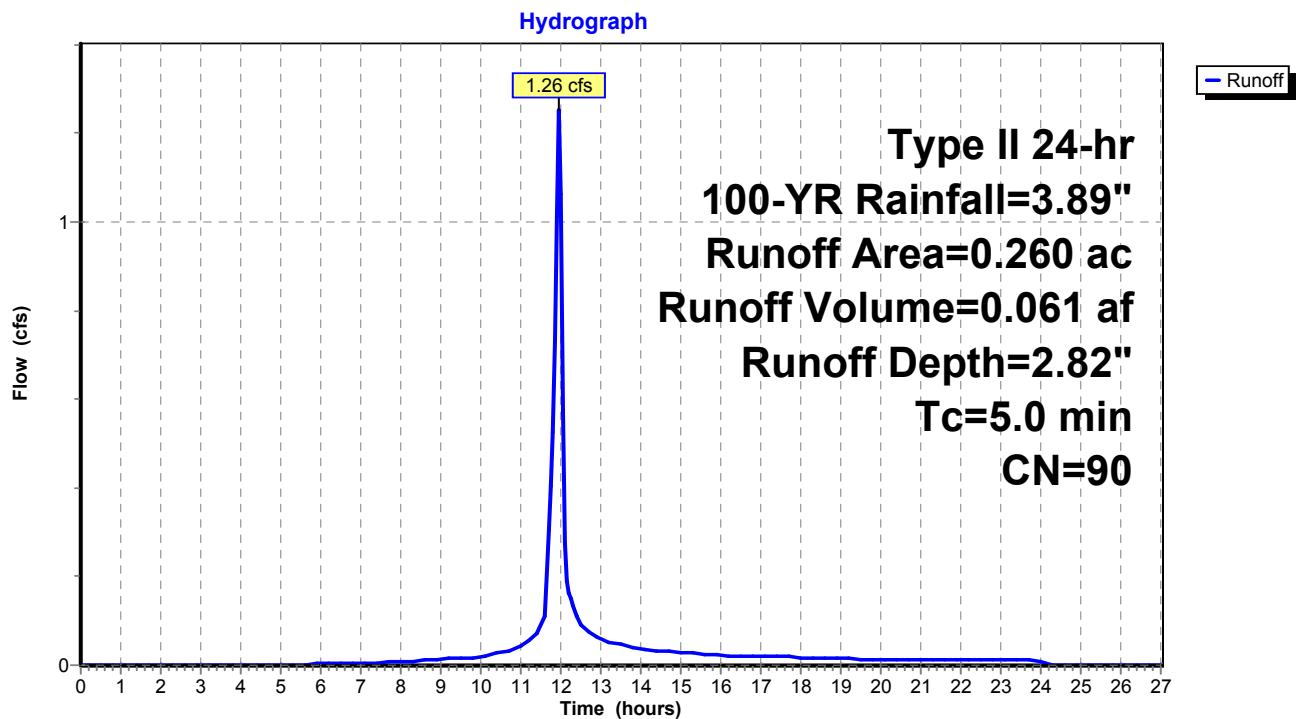
Runoff = 1.26 cfs @ 11.95 hrs, Volume= 0.061 af, Depth= 2.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.030	98	10% Impervious
0.100	85	Desert shrub range, Poor, HSG C
0.130	91	Newly graded area, HSG C
0.260	90	Weighted Average
0.230		88.46% Pervious Area
0.030		11.54% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 12: Watershed 12



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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 13: Watershed 13

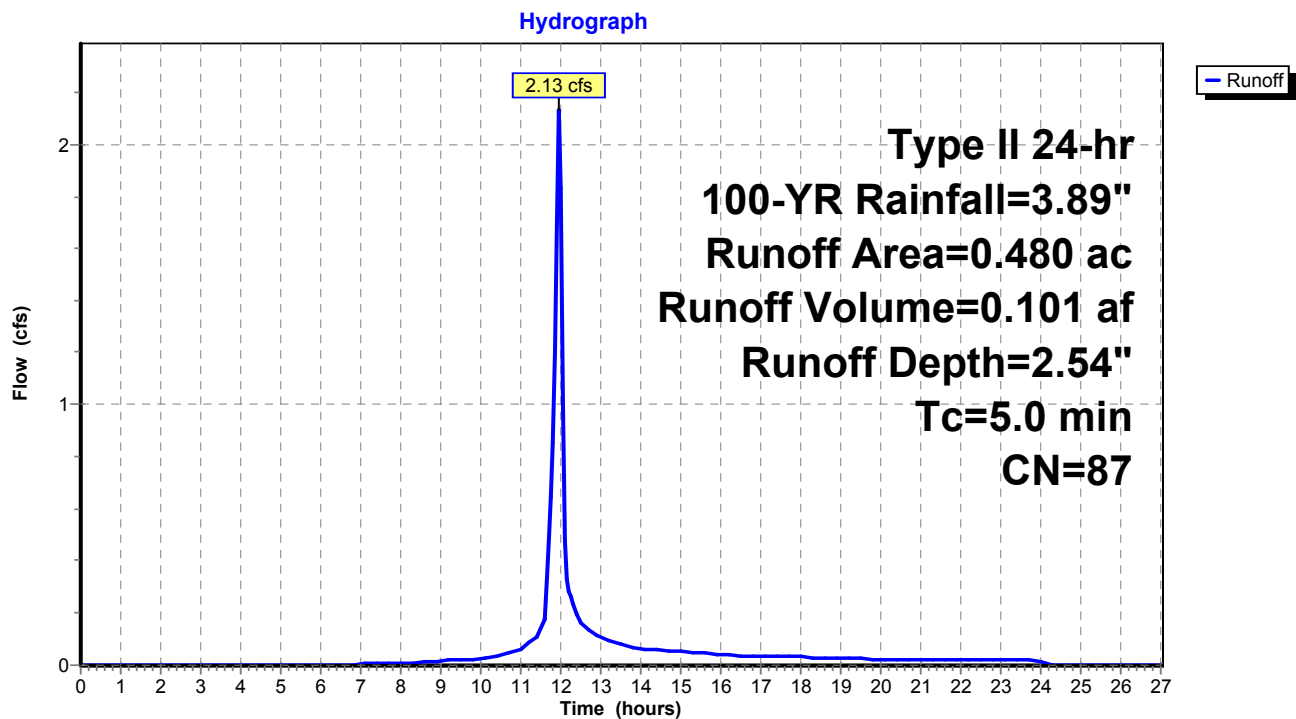
Runoff = 2.13 cfs @ 11.95 hrs, Volume= 0.101 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.050	98	10% Impervious
0.380	85	Desert shrub range, Poor, HSG C
0.050	91	Newly graded area, HSG C
0.480	87	Weighted Average
0.430		89.58% Pervious Area
0.050		10.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 13: Watershed 13



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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 14: Watershed 14

Runoff = 192.93 cfs @ 12.29 hrs, Volume= 20.338 af, Depth= 2.45"

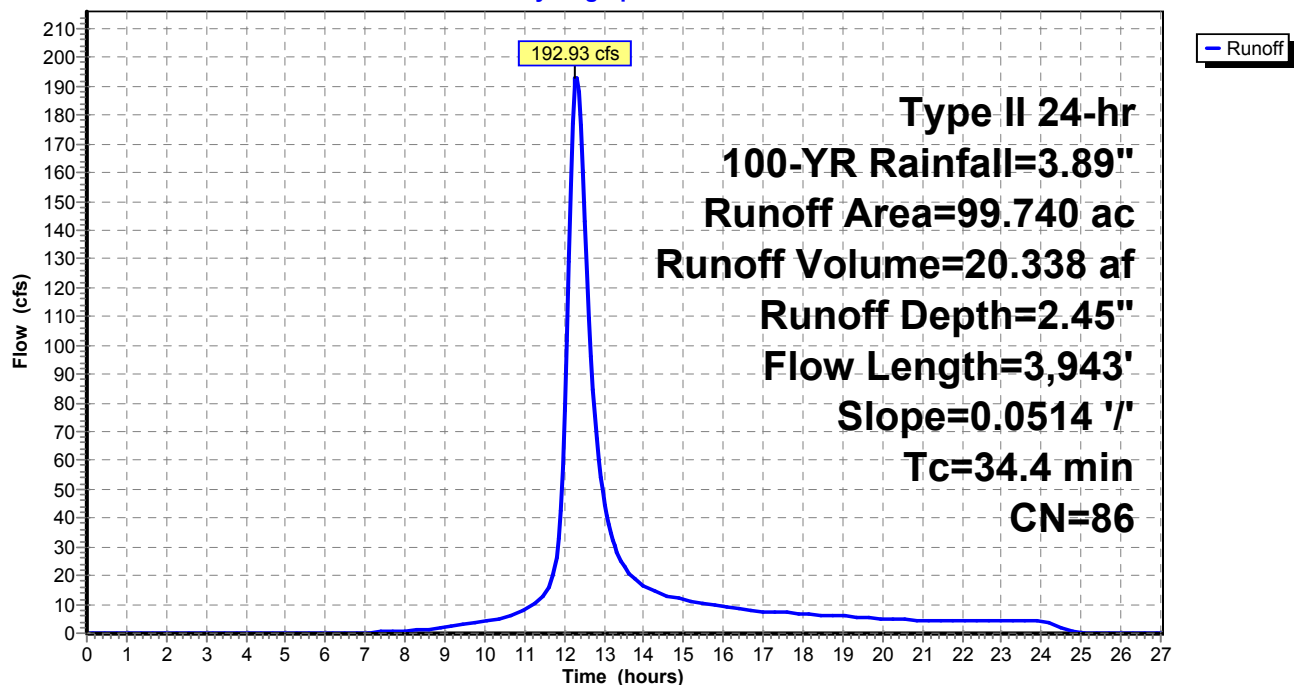
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 9.970	98	10% Impervious
89.770	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
99.740	86	Weighted Average
89.770		90.00% Pervious Area
9.970		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.4	3,943	0.0514	1.91		Lag/CN Method,

Subcatchment 14: Watershed 14

Hydrograph



Plant Site Developed WS 2

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 15: Watershed 15

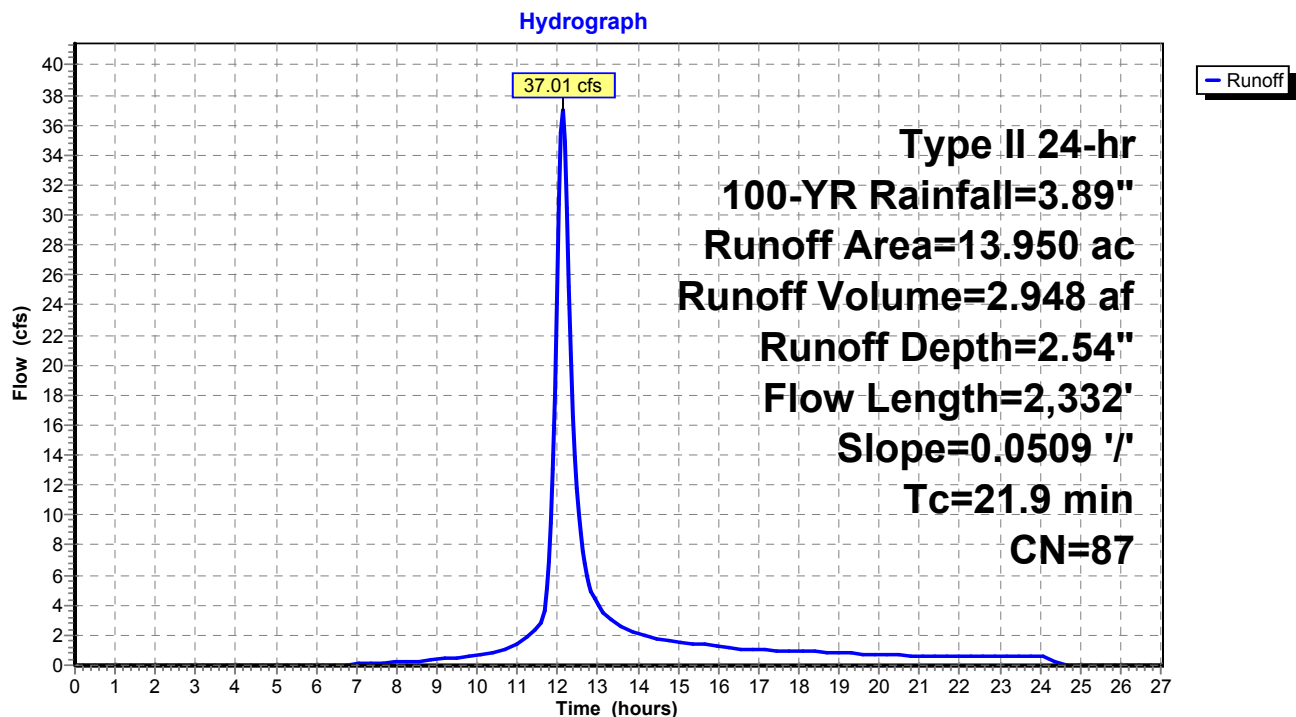
Runoff = 37.01 cfs @ 12.15 hrs, Volume= 2.948 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 1.400	98	10% Impervious
11.850	85	Desert shrub range, Poor, HSG C
0.700	91	Newly graded area, HSG C
13.950	87	Weighted Average
12.550		89.96% Pervious Area
1.400		10.04% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.9	2,332	0.0509	1.78		Lag/CN Method,

Subcatchment 15: Watershed 15



Plant Site Developed WS 2

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 16: Watershed 16

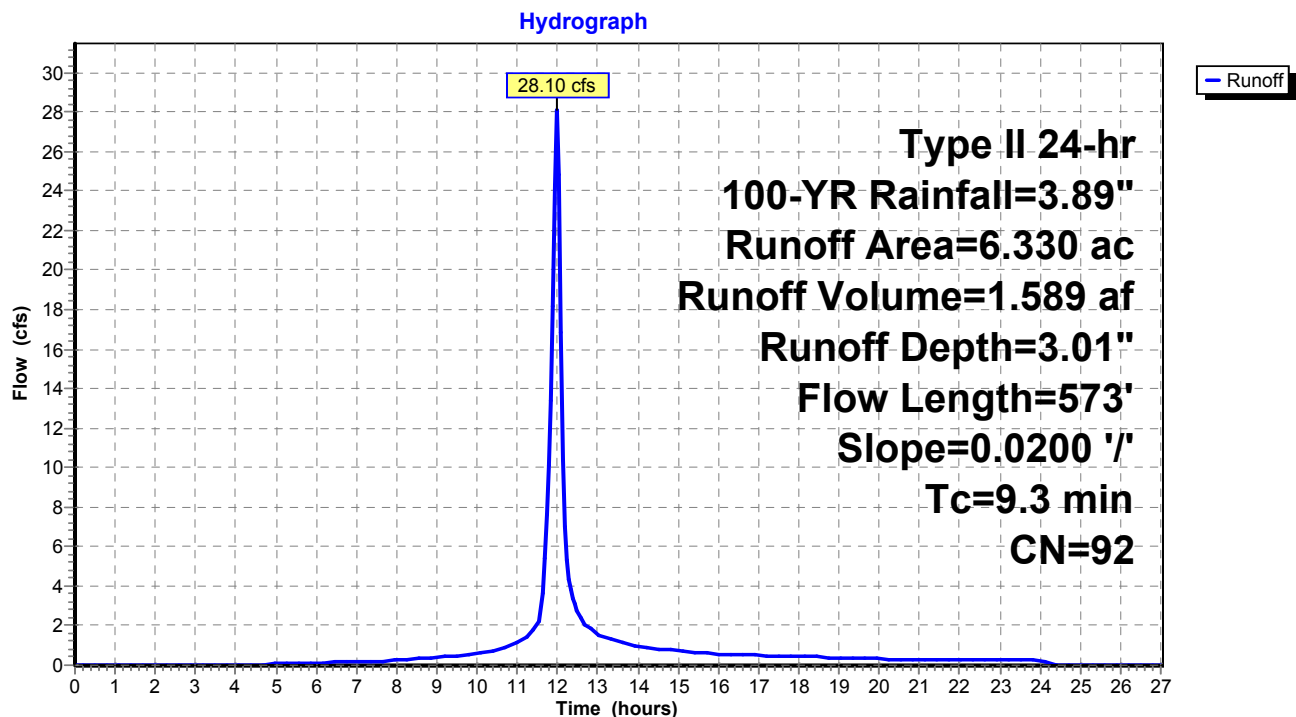
Runoff = 28.10 cfs @ 12.00 hrs, Volume= 1.589 af, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.630	98	10% Impervious
0.000	85	Desert shrub range, Poor, HSG C
5.700	91	Newly graded area, HSG C
6.330	92	Weighted Average
5.700		90.05% Pervious Area
0.630		9.95% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	573	0.0200	1.03		Lag/CN Method,

Subcatchment 16: Watershed 16



Plant Site Developed WS 2

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 17: Watershed 17

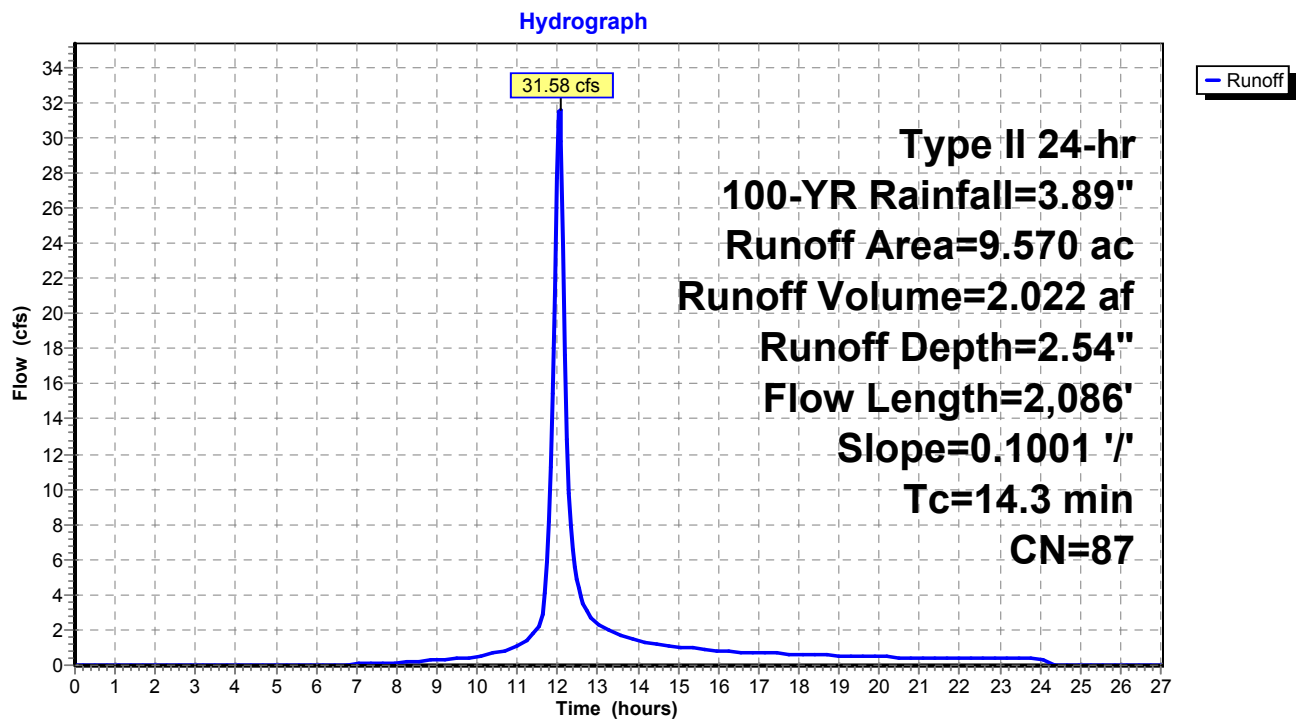
Runoff = 31.58 cfs @ 12.06 hrs, Volume= 2.022 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.960	98	10% Impervious
8.130	85	Desert shrub range, Poor, HSG C
0.480	91	Newly graded area, HSG C
9.570	87	Weighted Average
8.610		89.97% Pervious Area
0.960		10.03% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.3	2,086	0.1001	2.44		Lag/CN Method,

Subcatchment 17: Watershed 17



Plant Site Developed WS 2

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Summary for Subcatchment 18: Watershed 18

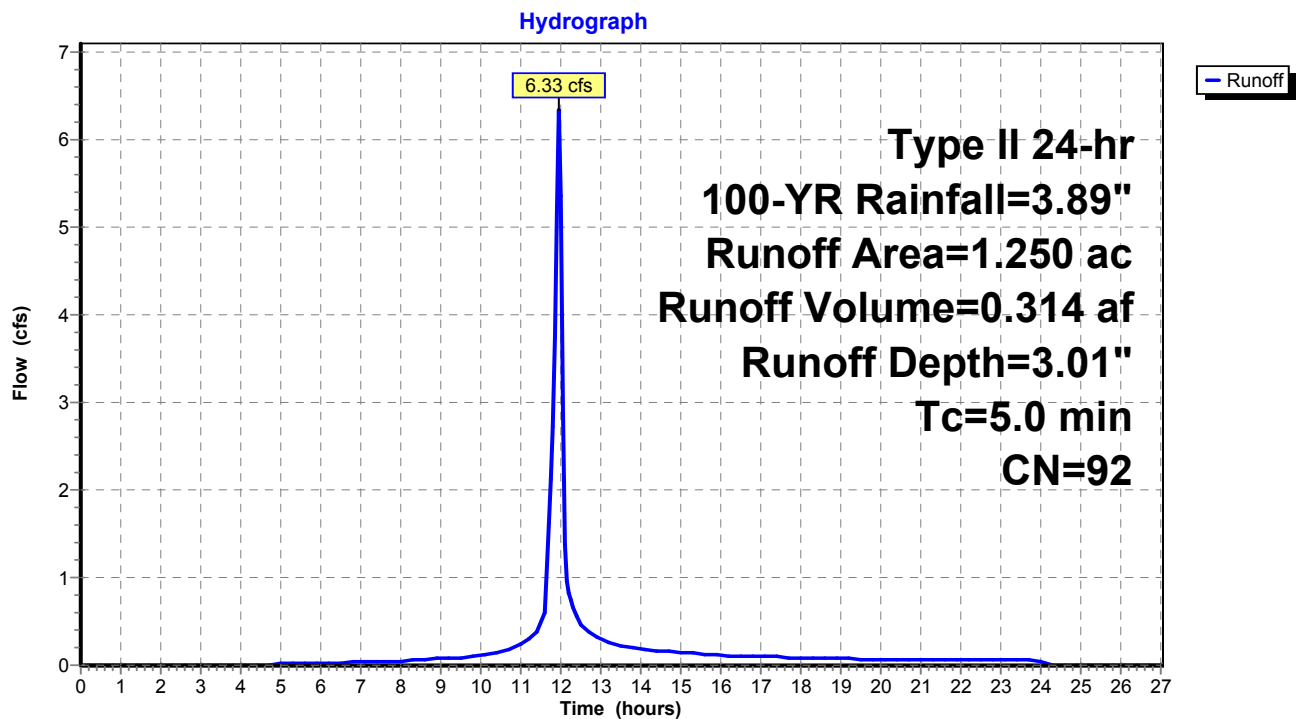
Runoff = 6.33 cfs @ 11.95 hrs, Volume= 0.314 af, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.120	98	10% Impervious
0.000	85	Desert shrub range, Poor, HSG C
1.130	91	Newly graded area, HSG C
1.250	92	Weighted Average
1.130		90.40% Pervious Area
0.120		9.60% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 18: Watershed 18



Plant Site Developed WS 2

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 19: Watershed 19

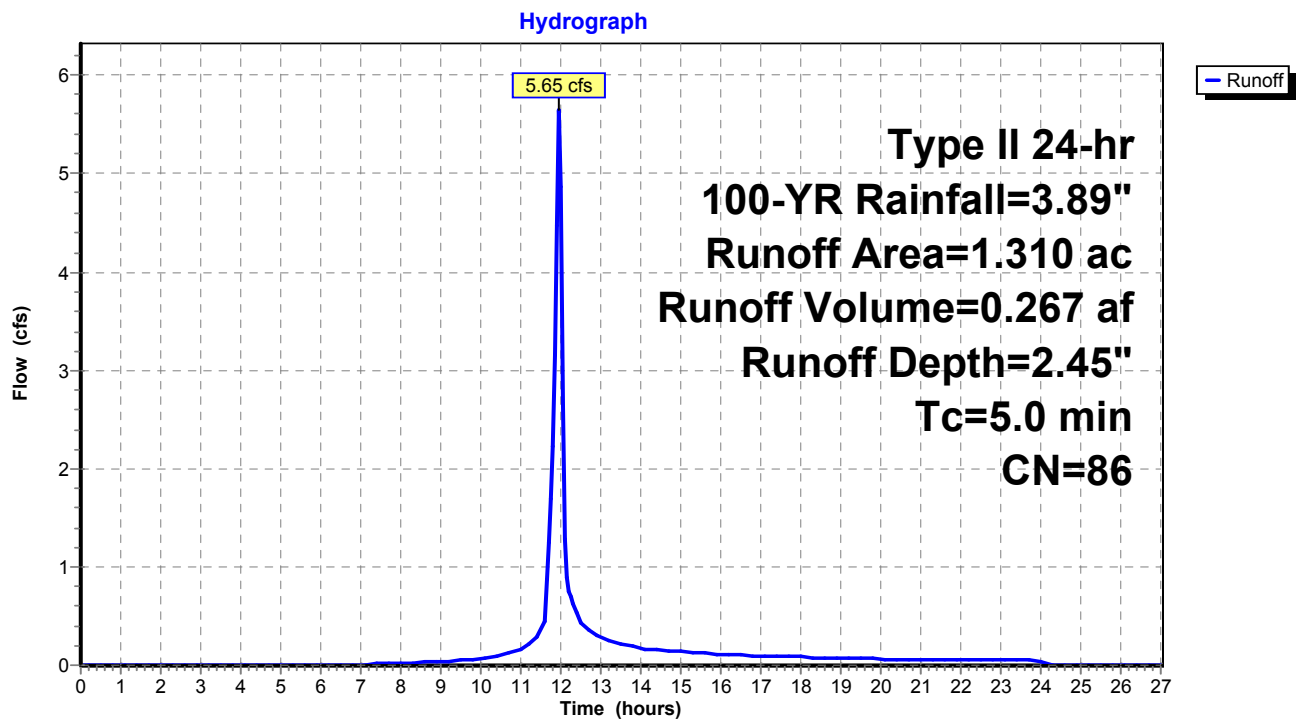
Runoff = 5.65 cfs @ 11.95 hrs, Volume= 0.267 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.130	98	10% Impervious
1.180	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
1.310	86	Weighted Average
1.180		90.08% Pervious Area
0.130		9.92% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment 19: Watershed 19



Plant Site Developed WS 2

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 20: Watershed 20

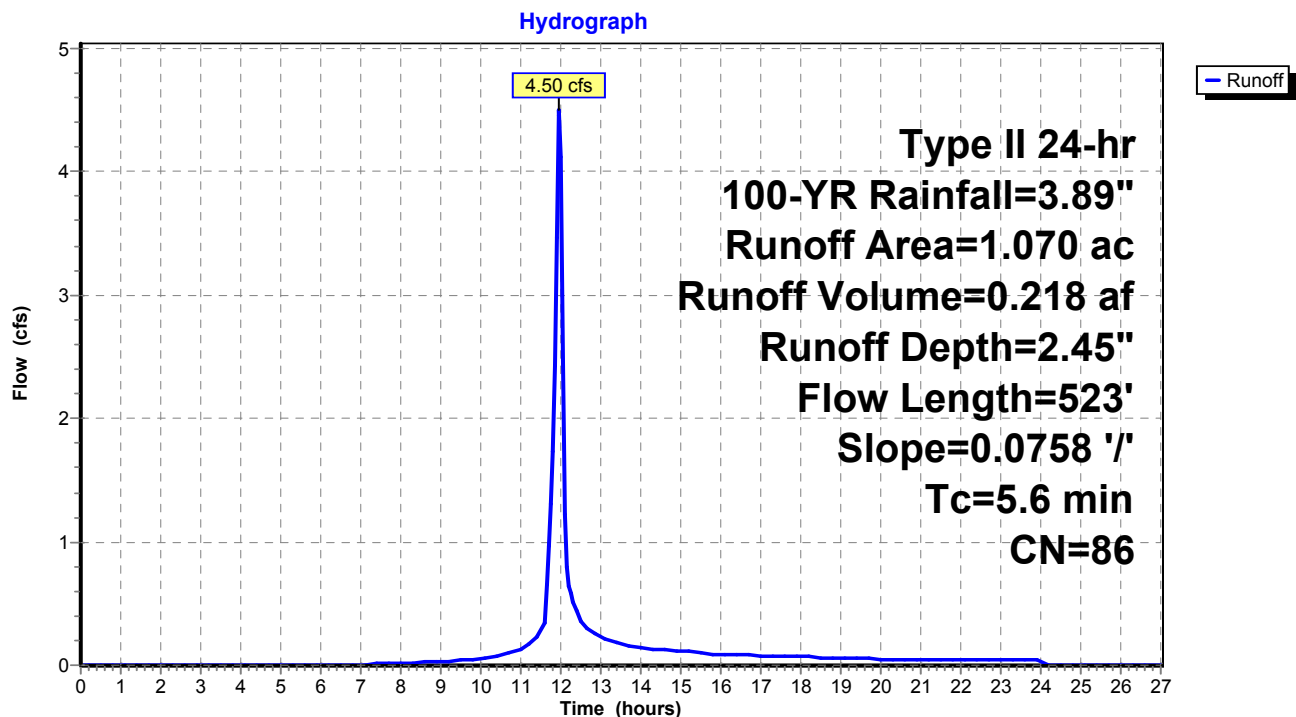
Runoff = 4.50 cfs @ 11.96 hrs, Volume= 0.218 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

	Area (ac)	CN	Description
*	0.110	98	10% Impervious
	0.960	85	Desert shrub range, Poor, HSG C
	0.000	91	Newly graded area, HSG C
	1.070	86	Weighted Average
	0.960		89.72% Pervious Area
	0.110		10.28% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	523	0.0758	1.55		Lag/CN Method,

Subcatchment 20: Watershed 20



Plant Site Developed WS 2

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment 21: Watershed 21

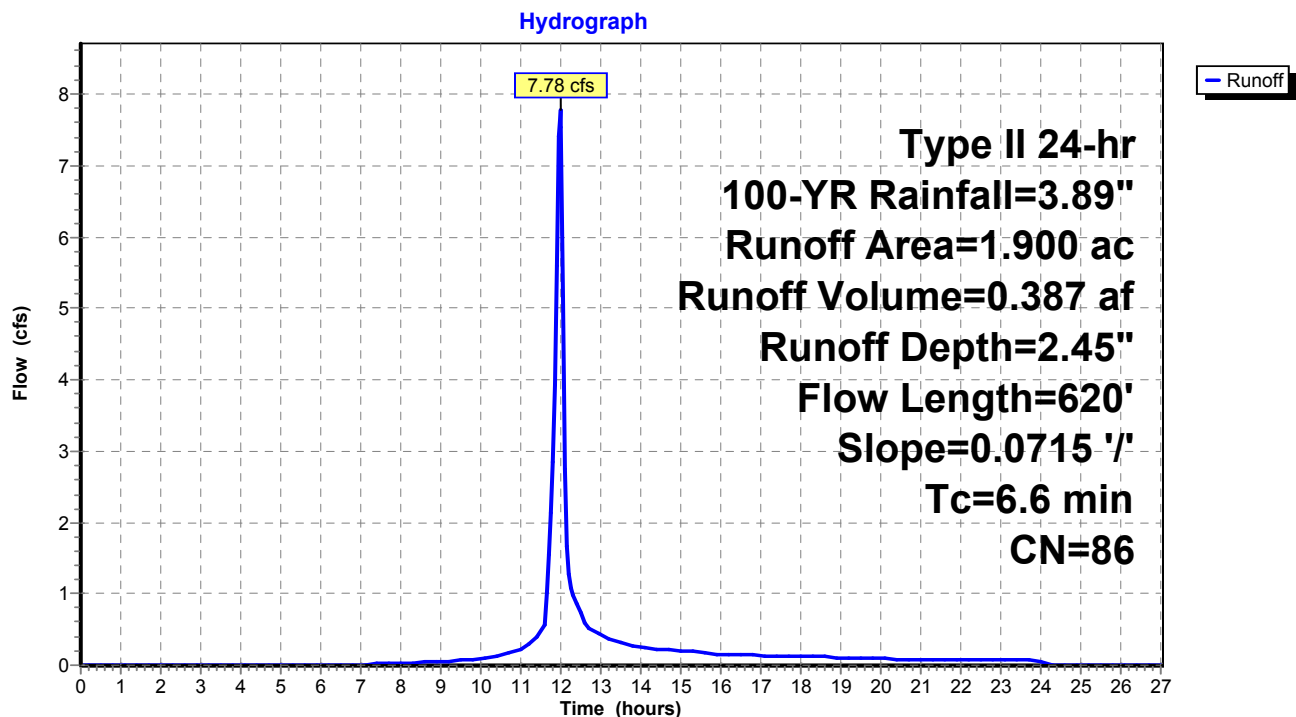
Runoff = 7.78 cfs @ 11.98 hrs, Volume= 0.387 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

	Area (ac)	CN	Description
*	0.190	98	10% Impervious
	1.710	85	Desert shrub range, Poor, HSG C
	0.000	91	Newly graded area, HSG C
	1.900	86	Weighted Average
	1.710		90.00% Pervious Area
	0.190		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	620	0.0715	1.56		Lag/CN Method,

Subcatchment 21: Watershed 21



Plant Site Developed WS 2

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment OFF 1: Offsite 1

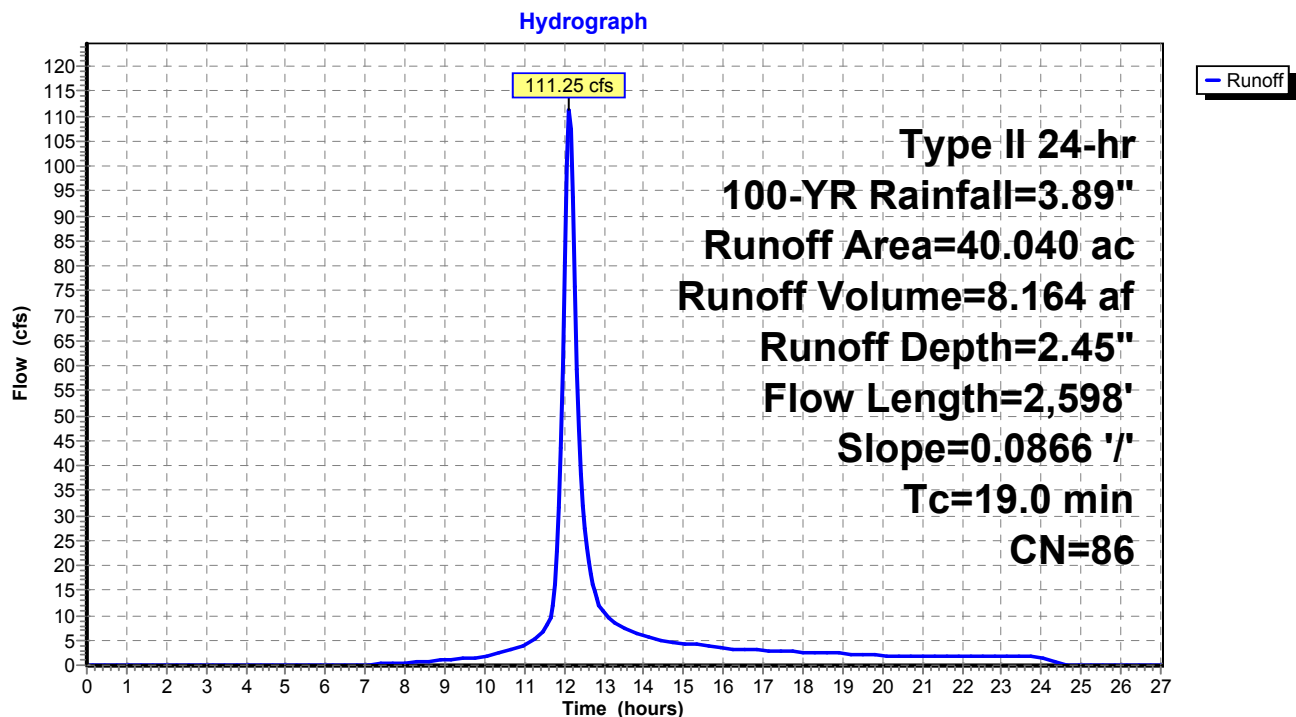
Runoff = 111.25 cfs @ 12.11 hrs, Volume= 8.164 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 4.000	98	10% Impervious
36.040	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
40.040	86	Weighted Average
36.040		90.01% Pervious Area
4.000		9.99% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.0	2,598	0.0866	2.28		Lag/CN Method,

Subcatchment OFF 1: Offsite 1



Plant Site Developed WS 2

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment OFF 2: Offsite 2

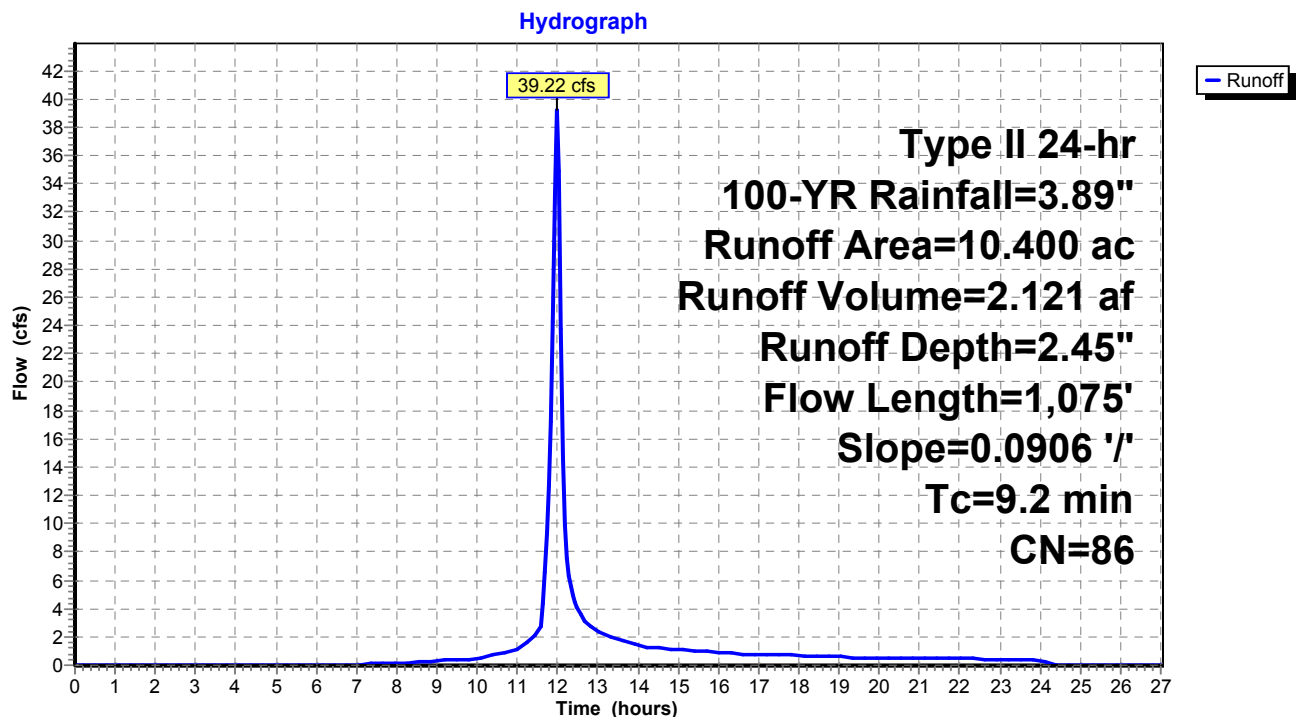
Runoff = 39.22 cfs @ 12.00 hrs, Volume= 2.121 af, Depth= 2.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 1.040	98	10% Impervious
9.360	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
10.400	86	Weighted Average
9.360		90.00% Pervious Area
1.040		10.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.2	1,075	0.0906	1.96		Lag/CN Method,

Subcatchment OFF 2: Offsite 2



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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment OFF 3: Offsite 3

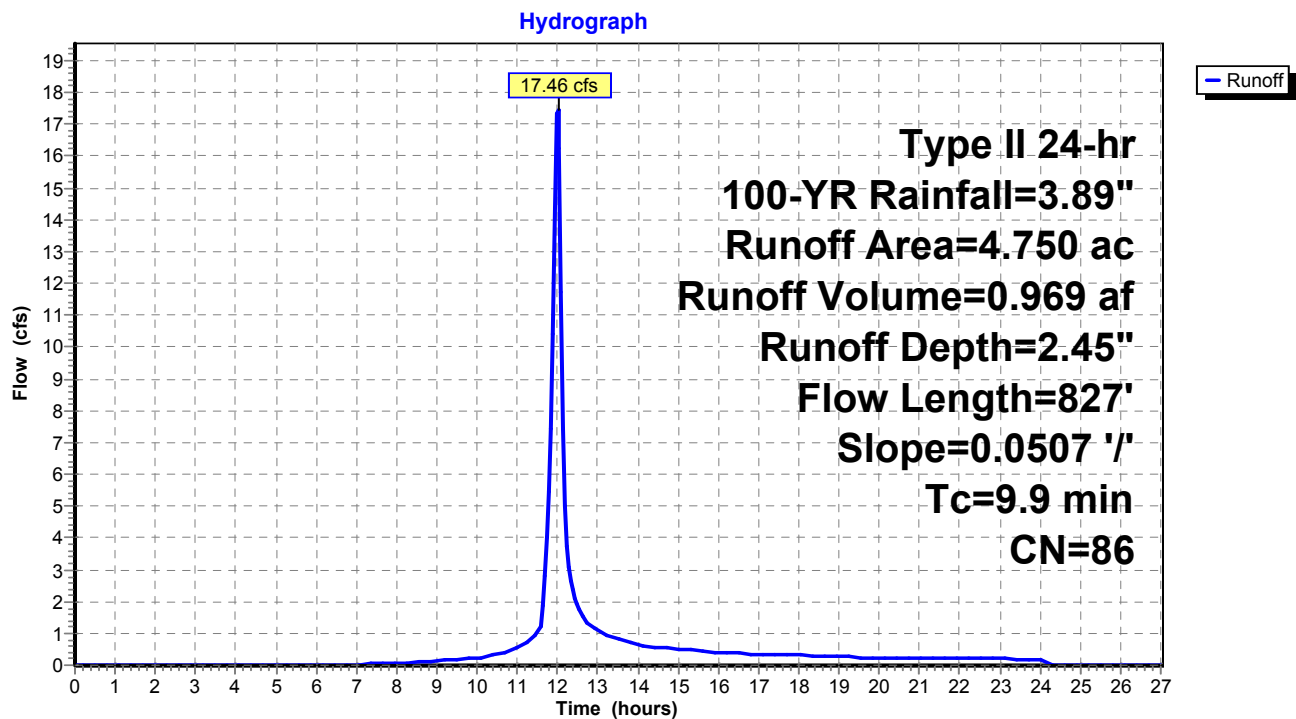
Runoff = 17.46 cfs @ 12.01 hrs, Volume= 0.969 af, Depth= 2.45"

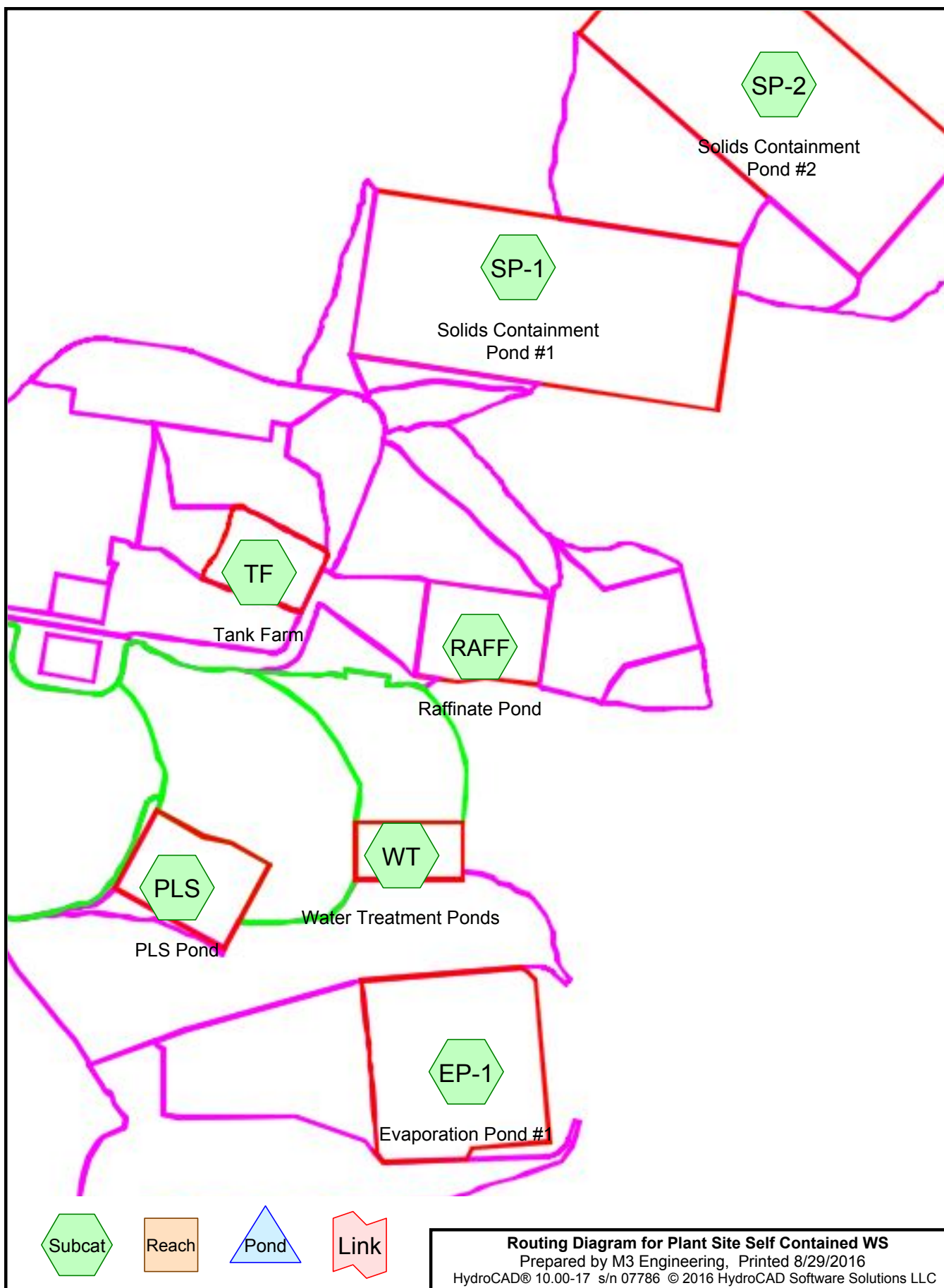
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 0.470	98	10% Impervious
4.280	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
4.750	86	Weighted Average
4.280		90.11% Pervious Area
0.470		9.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.9	827	0.0507	1.39		Lag/CN Method,

Subcatchment OFF 3: Offsite 3





Plant Site Self Contained WS

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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.510	85	Desert shrub range, Poor, HSG C (TF)
4.400	98	Impervious (RAFF, TF)
44.090	98	Impervious Liner (EP-1, PLS, SP-1, SP-2, WT)
2.370	91	Newly graded area, HSG C (EP-1, TF)
52.370	97	TOTAL AREA

Plant Site Self Contained WS*Type II 24-hr 100-YR Rainfall=3.89"*

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Time span=0.00-27.00 hrs, dt=0.05 hrs, 541 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

SubcatchmentEP-1: Evaporation Pond #1 Runoff Area=8.250 ac 80.00% Impervious Runoff Depth=3.54"
Tc=5.0 min CN=97 Runoff=45.58 cfs 2.435 af

SubcatchmentPLS: PLS Pond Runoff Area=3.040 ac 100.00% Impervious Runoff Depth=3.66"
Tc=5.0 min CN=98 Runoff=16.96 cfs 0.926 af

SubcatchmentRAFF: Raffinate Pond Runoff Area=3.040 ac 100.00% Impervious Runoff Depth=3.66"
Tc=5.0 min CN=98 Runoff=16.96 cfs 0.926 af

SubcatchmentSP-1: Solids Containment Runoff Area=16.410 ac 100.00% Impervious Runoff Depth=3.66"
Tc=5.0 min CN=98 Runoff=91.54 cfs 4.999 af

SubcatchmentSP-2: Solids Containment Runoff Area=16.410 ac 100.00% Impervious Runoff Depth=3.66"
Tc=5.0 min CN=98 Runoff=91.54 cfs 4.999 af

SubcatchmentTF: Tank Farm Runoff Area=3.590 ac 37.88% Impervious Runoff Depth=2.91"
Flow Length=651' Slope=0.0700 '/' Tc=5.7 min CN=91 Runoff=17.26 cfs 0.871 af

SubcatchmentWT: Water Treatment Runoff Area=1.630 ac 100.00% Impervious Runoff Depth=3.66"
Tc=5.0 min CN=98 Runoff=9.09 cfs 0.497 af

Total Runoff Area = 52.370 ac Runoff Volume = 15.652 af Average Runoff Depth = 3.59"
7.41% Pervious = 3.880 ac 92.59% Impervious = 48.490 ac

Plant Site Self Contained WS

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment EP-1: Evaporation Pond #1

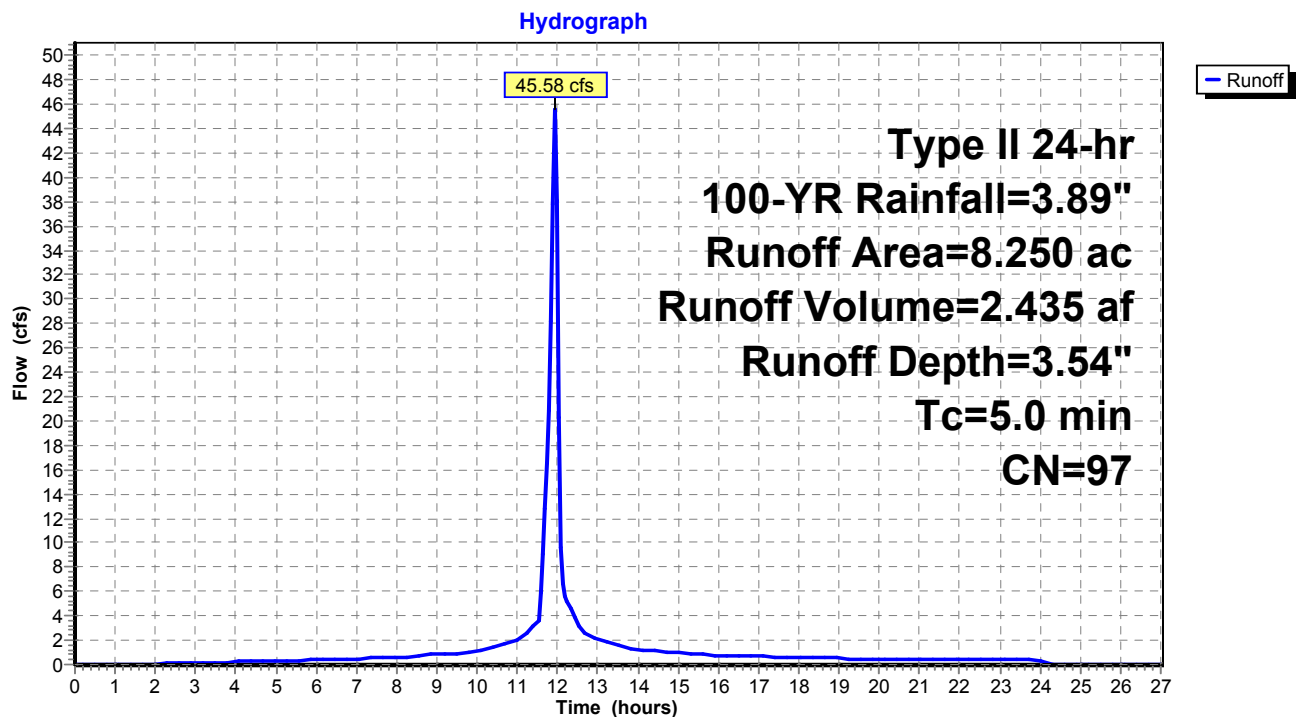
Runoff = 45.58 cfs @ 11.95 hrs, Volume= 2.435 af, Depth= 3.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 6.600	98	Impervious Liner
1.650	91	Newly graded area, HSG C
8.250	97	Weighted Average
1.650		20.00% Pervious Area
6.600		80.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment EP-1: Evaporation Pond #1



Plant Site Self Contained WS

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment PLS: PLS Pond

Runoff = 16.96 cfs @ 11.95 hrs, Volume= 0.926 af, Depth= 3.66"

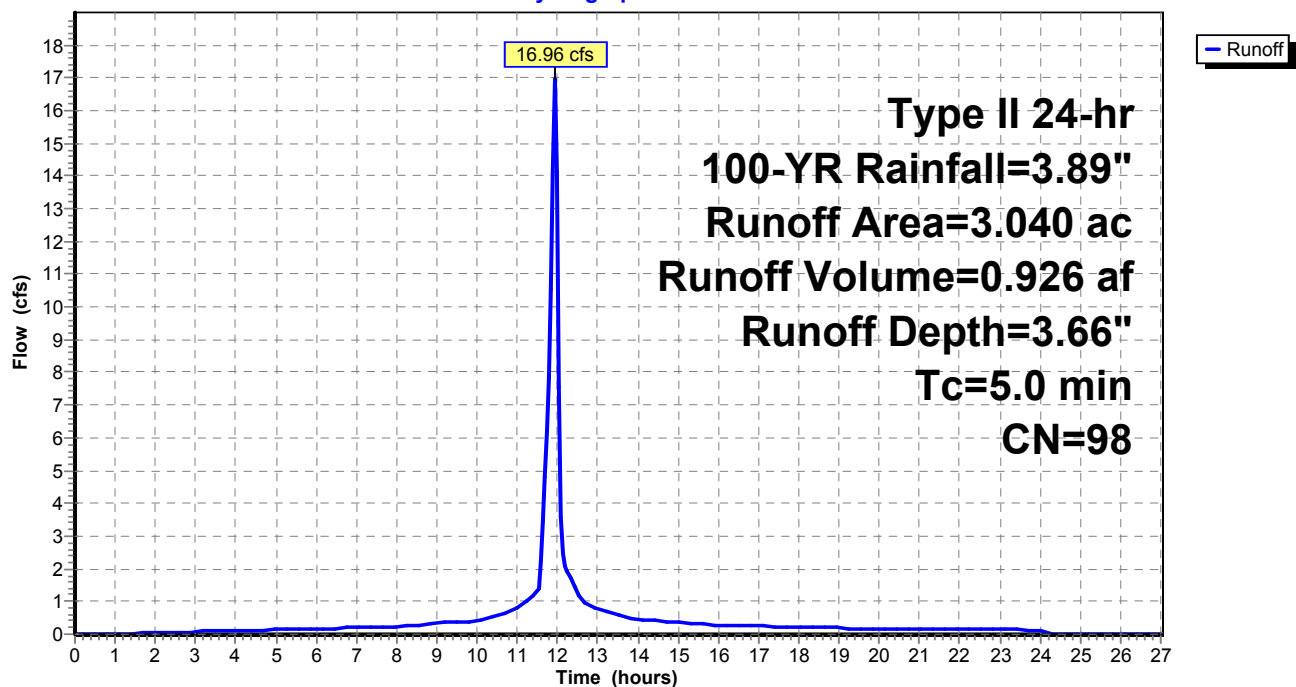
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 3.040	98	Impervious Liner
3.040		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment PLS: PLS Pond

Hydrograph



Plant Site Self Contained WS

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment RAFF: Raffinate Pond

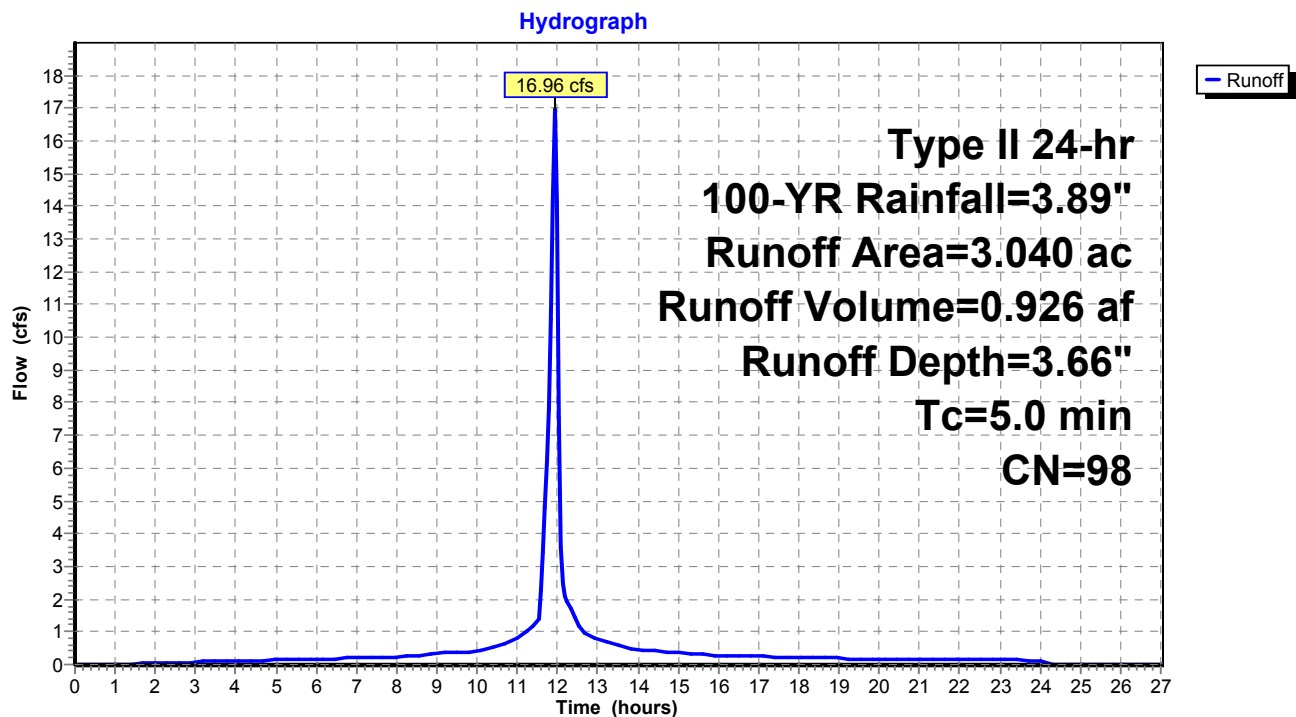
Runoff = 16.96 cfs @ 11.95 hrs, Volume= 0.926 af, Depth= 3.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 3.040	98	Impervious
0.000	85	Desert shrub range, Poor, HSG C
0.000	91	Newly graded area, HSG C
3.040	98	Weighted Average
3.040		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment RAFF: Raffinate Pond



Plant Site Self Contained WS

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment SP-1: Solids Containment Pond #1

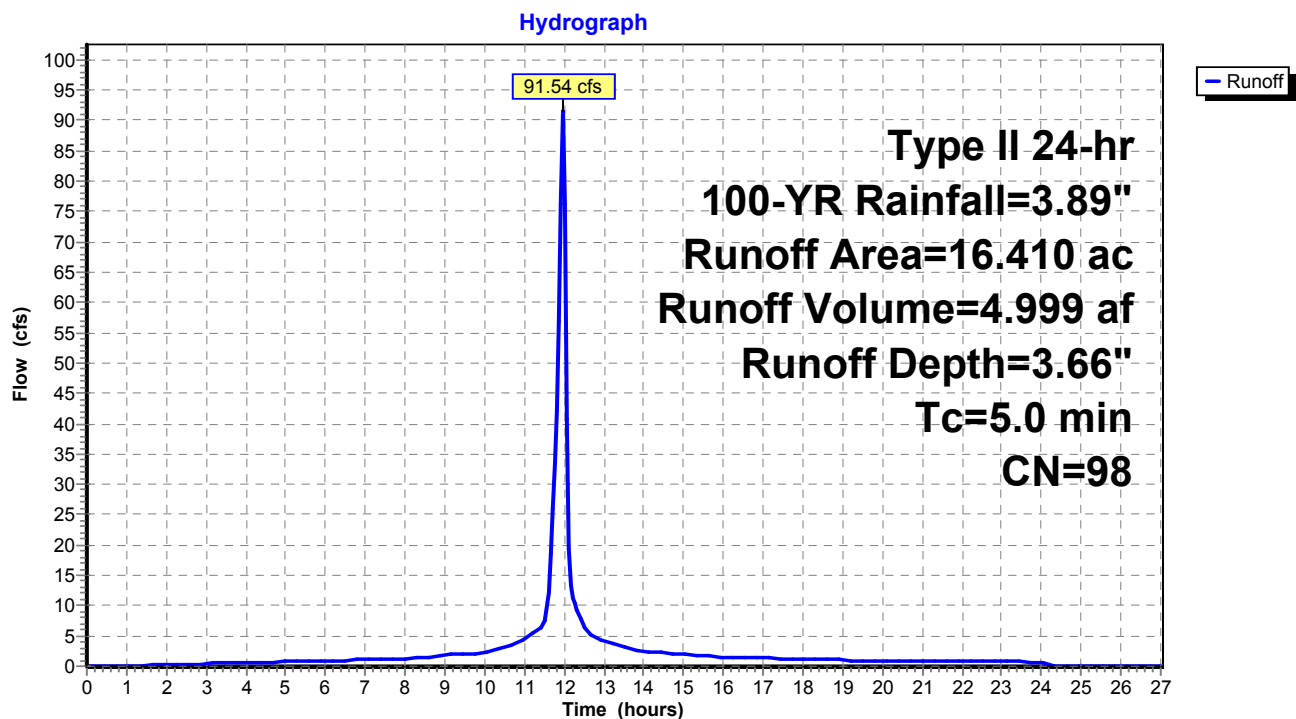
Runoff = 91.54 cfs @ 11.95 hrs, Volume= 4.999 af, Depth= 3.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 16.410	98	Impervious Liner
16.410		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment SP-1: Solids Containment Pond #1



Plant Site Self Contained WS

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment SP-2: Solids Containment Pond #2

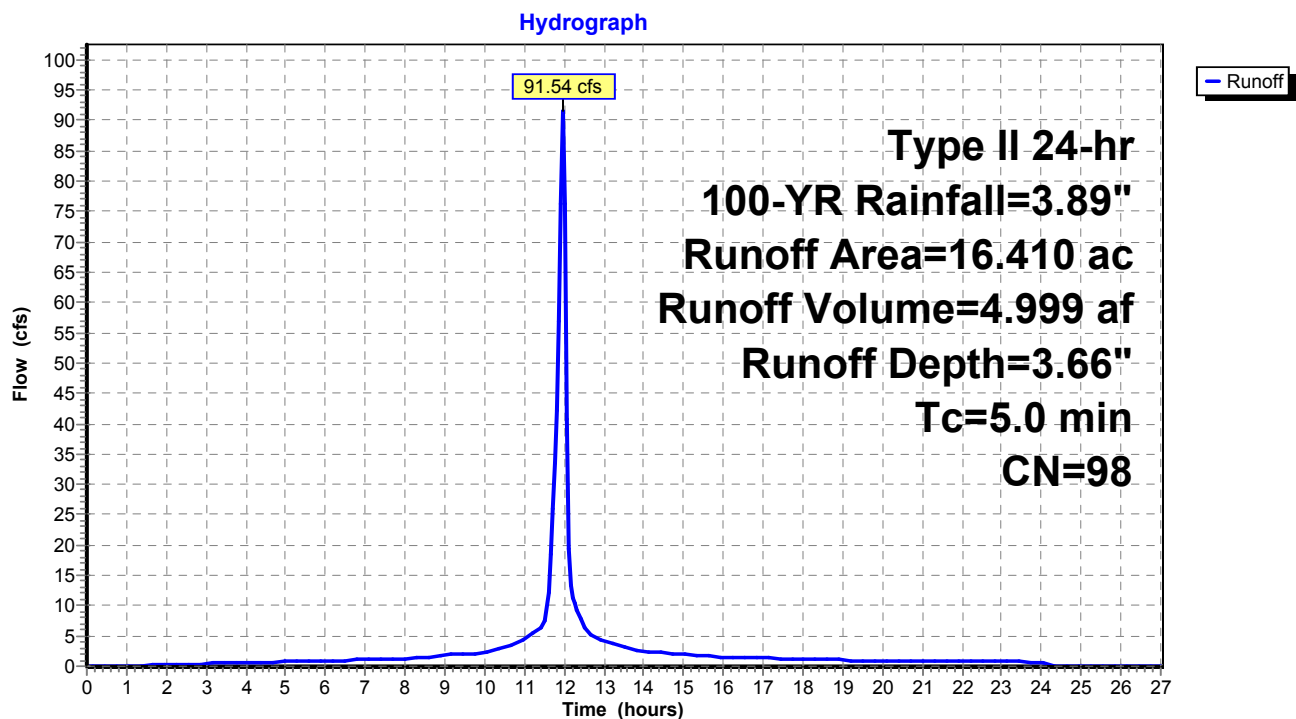
Runoff = 91.54 cfs @ 11.95 hrs, Volume= 4.999 af, Depth= 3.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 16.410	98	Impervious Liner
16.410		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment SP-2: Solids Containment Pond #2



Plant Site Self Contained WS

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment TF: Tank Farm

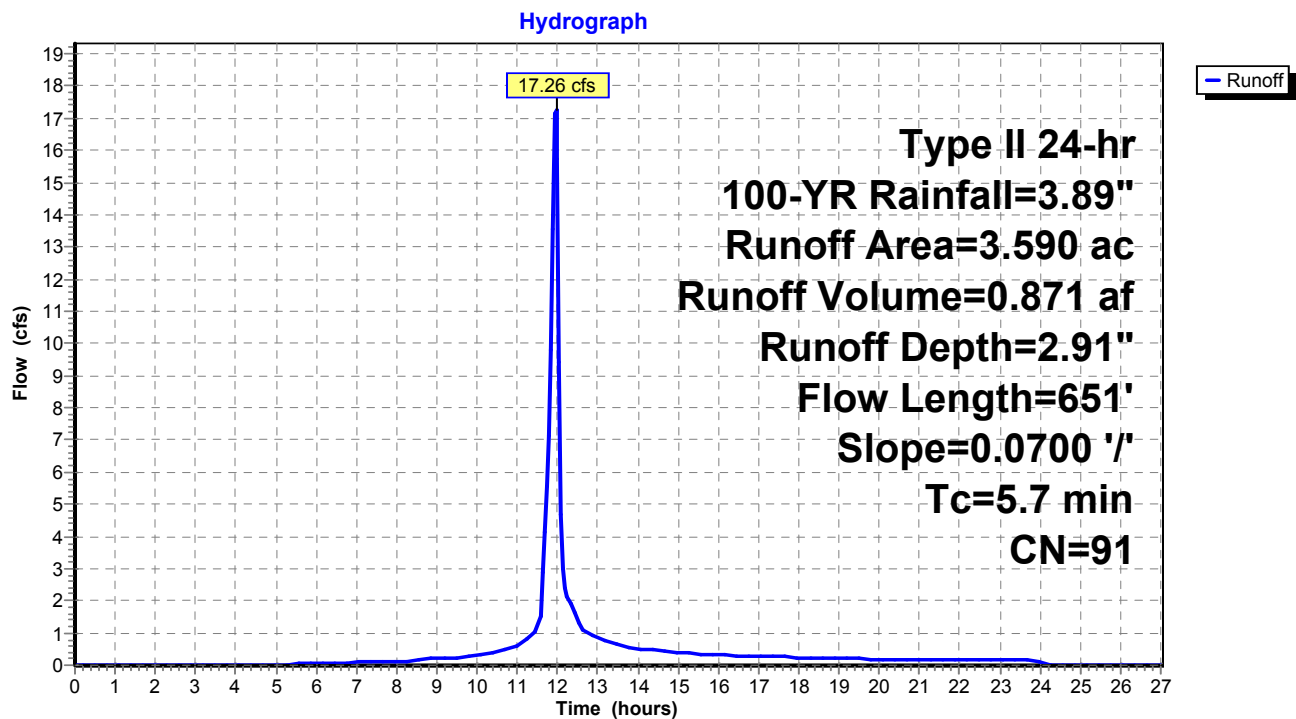
Runoff = 17.26 cfs @ 11.96 hrs, Volume= 0.871 af, Depth= 2.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 1.360	98	Impervious
1.510	85	Desert shrub range, Poor, HSG C
0.720	91	Newly graded area, HSG C
3.590	91	Weighted Average
2.230		62.12% Pervious Area
1.360		37.88% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	651	0.0700	1.89		Lag/CN Method,

Subcatchment TF: Tank Farm



Plant Site Self Contained WS

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Type II 24-hr 100-YR Rainfall=3.89"

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Summary for Subcatchment WT: Water Treatment Ponds

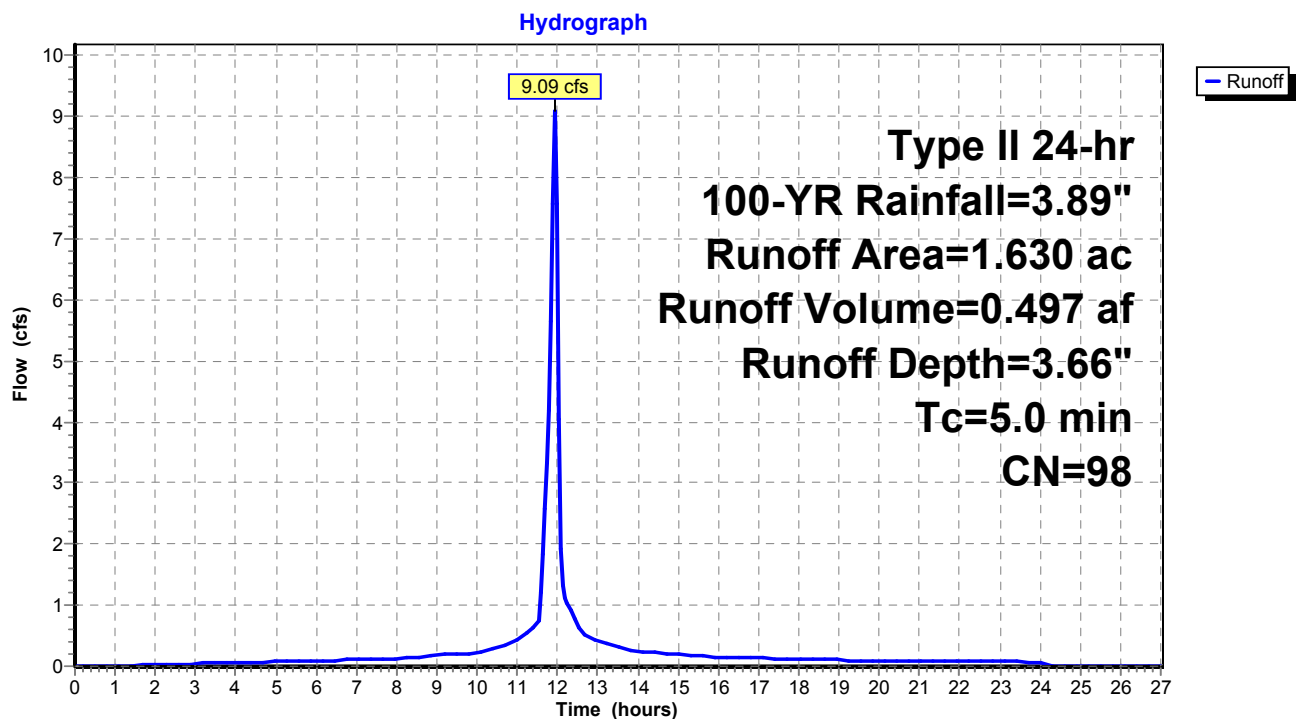
Runoff = 9.09 cfs @ 11.95 hrs, Volume= 0.497 af, Depth= 3.66"

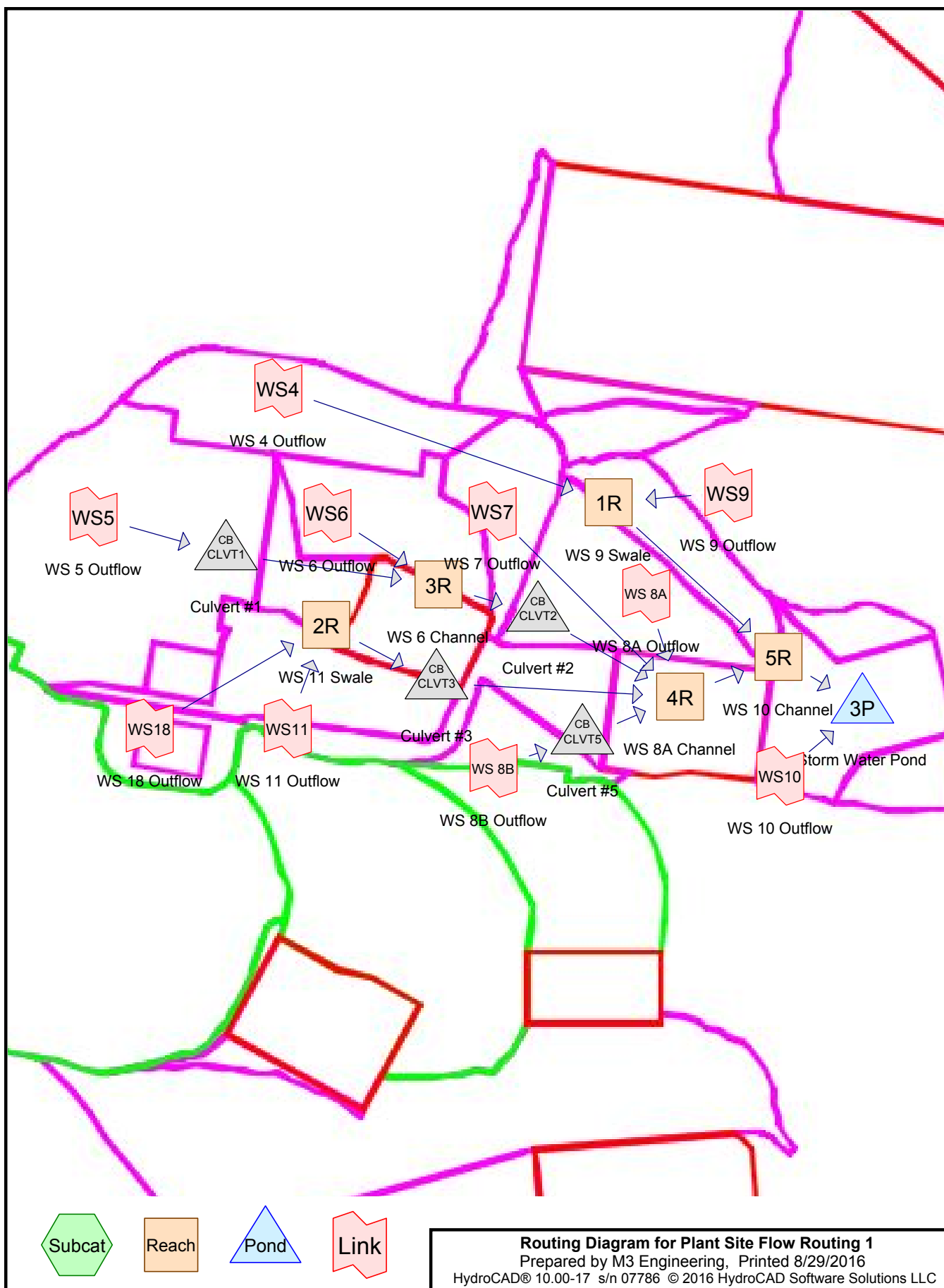
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YR Rainfall=3.89"

Area (ac)	CN	Description
* 1.630	98	Impervious Liner
1.630		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					Direct Entry, Minimum Tc

Subcatchment WT: Water Treatment Ponds





Plant Site Flow Routing 1

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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.000	0	TOTAL AREA

Plant Site Flow Routing 1

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Type II 24-hr 100-YR Rainfall=3.89"

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Time span=0.00-27.00 hrs, dt=0.05 hrs, 541 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Reach 1R: WS 9 Swale Avg. Flow Depth=1.32' Max Vel=7.36 fps Inflow=26.36 cfs 1.670 af
n=0.035 L=774.0' S=0.0607 ' ' Capacity=229.08 cfs Outflow=25.00 cfs 1.670 af

Reach 2R: WS 11 Swale Avg. Flow Depth=1.32' Max Vel=5.05 fps Inflow=18.23 cfs 1.137 af
n=0.035 L=554.0' S=0.0289 ' ' Capacity=157.99 cfs Outflow=17.25 cfs 1.137 af

Reach 3R: WS 6 Channel Avg. Flow Depth=1.50' Max Vel=6.42 fps Inflow=69.08 cfs 3.606 af
n=0.035 L=549.0' S=0.0237 ' ' Capacity=281.64 cfs Outflow=64.68 cfs 3.606 af

Reach 4R: WS 8A Channel Avg. Flow Depth=1.80' Max Vel=7.32 fps Inflow=118.24 cfs 6.821 af
n=0.035 L=713.0' S=0.0238 ' ' Capacity=319.17 cfs Outflow=111.10 cfs 6.821 af

Reach 5R: WS 10 Channel Avg. Flow Depth=2.14' Max Vel=6.74 fps Inflow=135.54 cfs 8.491 af
n=0.035 L=239.0' S=0.0167 ' ' Capacity=267.40 cfs Outflow=131.64 cfs 8.491 af

Pond 3P: Storm Water Pond Inflow=138.08 cfs 9.366 af
Primary=138.08 cfs 9.366 af

Pond CLVT1: Culvert #1 Peak Elev=4,802.86' Inflow=55.18 cfs 2.886 af
48.0" Round Culvert n=0.025 L=200.0' S=0.0300 ' ' Outflow=55.18 cfs 2.886 af

Pond CLVT2: Culvert #2 Peak Elev=4,773.17' Inflow=64.68 cfs 3.606 af
48.0" Round Culvert n=0.025 L=116.0' S=0.0259 ' ' Outflow=64.68 cfs 3.606 af

Pond CLVT3: Culvert #3 Peak Elev=4,772.08' Inflow=17.25 cfs 1.137 af
30.0" Round Culvert n=0.025 L=220.0' S=0.0136 ' ' Outflow=17.25 cfs 1.137 af

Pond CLVT5: Culvert #5 Peak Elev=4,762.18' Inflow=12.17 cfs 0.655 af
30.0" Round Culvert n=0.025 L=245.5' S=0.0189 ' ' Outflow=12.17 cfs 0.655 af

Link WS 100-YR Runoff Imported from Plant Site Developed WS~Subcat 8A.hce Inflow=15.69 cfs 0.836 af
Area= 4.100 ac 10.00% Imperv. Primary=15.69 cfs 0.836 af

Link WS 100-YR Runoff Imported from Plant Site Developed WS~Subcat 8B.hce Inflow=12.17 cfs 0.655 af
Area= 2.890 ac 10.03% Imperv. Primary=12.17 cfs 0.655 af

Link WS10: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 10.hce Inflow=16.97 cfs 0.875 af
Area= 3.160 ac 50.00% Imperv. Primary=16.97 cfs 0.875 af

Link WS11: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 11.hce Inflow=13.66 cfs 0.823 af
Area= 3.760 ac 10.11% Imperv. Primary=13.66 cfs 0.823 af

Link 100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 18.hce Inflow=6.33 cfs 0.314 af
Area= 1.250 ac 9.60% Imperv. Primary=6.33 cfs 0.314 af

Link WS4: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 4.hce Inflow=17.85 cfs 1.164 af
Area= 4.640 ac 9.91% Imperv. Primary=17.85 cfs 1.164 af

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Link WS5: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 5.hce Inflow=55.18 cfs 2.886 af
Area= 11.500 ac 10.00% Imperv. Primary=55.18 cfs 2.886 af

Link WS6: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 6.hce Inflow=14.67 cfs 0.720 af
Area= 3.290 ac 10.03% Imperv. Primary=14.67 cfs 0.720 af

Link WS7: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 7.hce Inflow=11.98 cfs 0.587 af
Area= 2.420 ac 9.92% Imperv. Primary=11.98 cfs 0.587 af

Link WS9: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 9.hce Inflow=9.63 cfs 0.506 af
Area= 2.480 ac 10.08% Imperv. Primary=9.63 cfs 0.506 af

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Summary for Reach 1R: WS 9 Swale

Inflow Area = 7.120 ac, 9.97% Impervious, Inflow Depth = 2.81" for 100-YR event
Inflow = 26.36 cfs @ 12.03 hrs, Volume= 1.670 af
Outflow = 25.00 cfs @ 12.08 hrs, Volume= 1.670 af, Atten= 5%, Lag= 3.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Max. Velocity= 7.36 fps, Min. Travel Time= 1.8 min

Avg. Velocity = 2.54 fps, Avg. Travel Time= 5.1 min

Peak Storage= 2,696 cf @ 12.05 hrs

Average Depth at Peak Storage= 1.32'

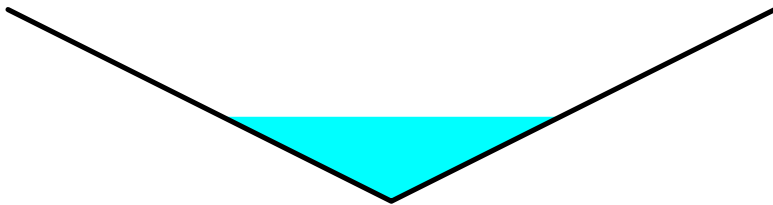
Bank-Full Depth= 3.00' Flow Area= 18.0 sf, Capacity= 229.08 cfs

0.00' x 3.00' deep channel, n= 0.035

Side Slope Z-value= 2.0 '/' Top Width= 12.00'

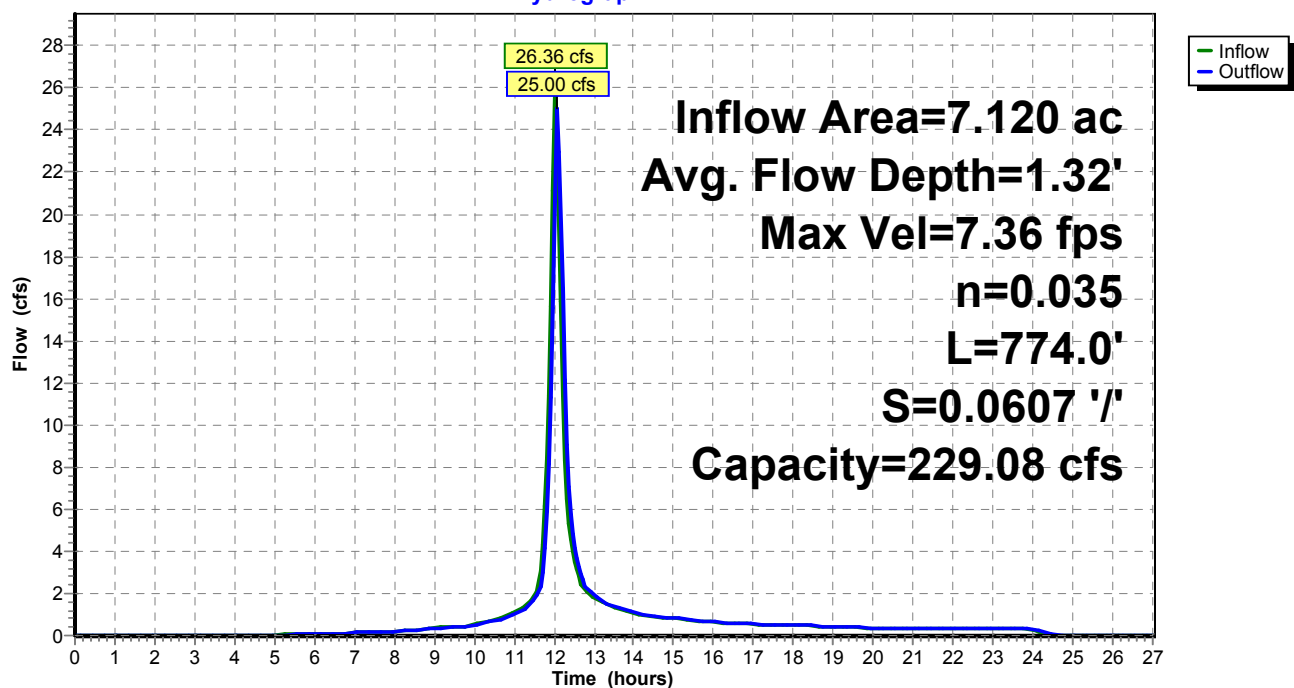
Length= 774.0' Slope= 0.0607 '/'

Inlet Invert= 4,797.00', Outlet Invert= 4,750.00'



Reach 1R: WS 9 Swale

Hydrograph



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Summary for Reach 2R: WS 11 Swale

Inflow Area = 5.010 ac, 9.98% Impervious, Inflow Depth = 2.72" for 100-YR event
Inflow = 18.23 cfs @ 12.00 hrs, Volume= 1.137 af
Outflow = 17.25 cfs @ 12.05 hrs, Volume= 1.137 af, Atten= 5%, Lag= 3.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Max. Velocity= 5.05 fps, Min. Travel Time= 1.8 min

Avg. Velocity = 1.72 fps, Avg. Travel Time= 5.4 min

Peak Storage= 1,923 cf @ 12.02 hrs

Average Depth at Peak Storage= 1.32'

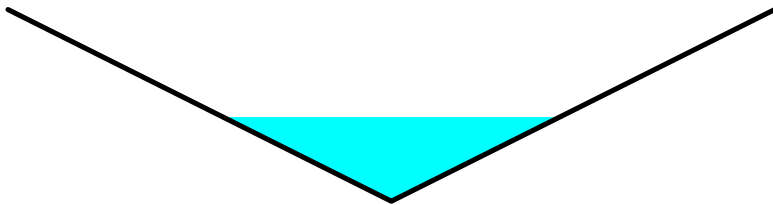
Bank-Full Depth= 3.00' Flow Area= 18.0 sf, Capacity= 157.99 cfs

0.00' x 3.00' deep channel, n= 0.035

Side Slope Z-value= 2.0 ' ' Top Width= 12.00'

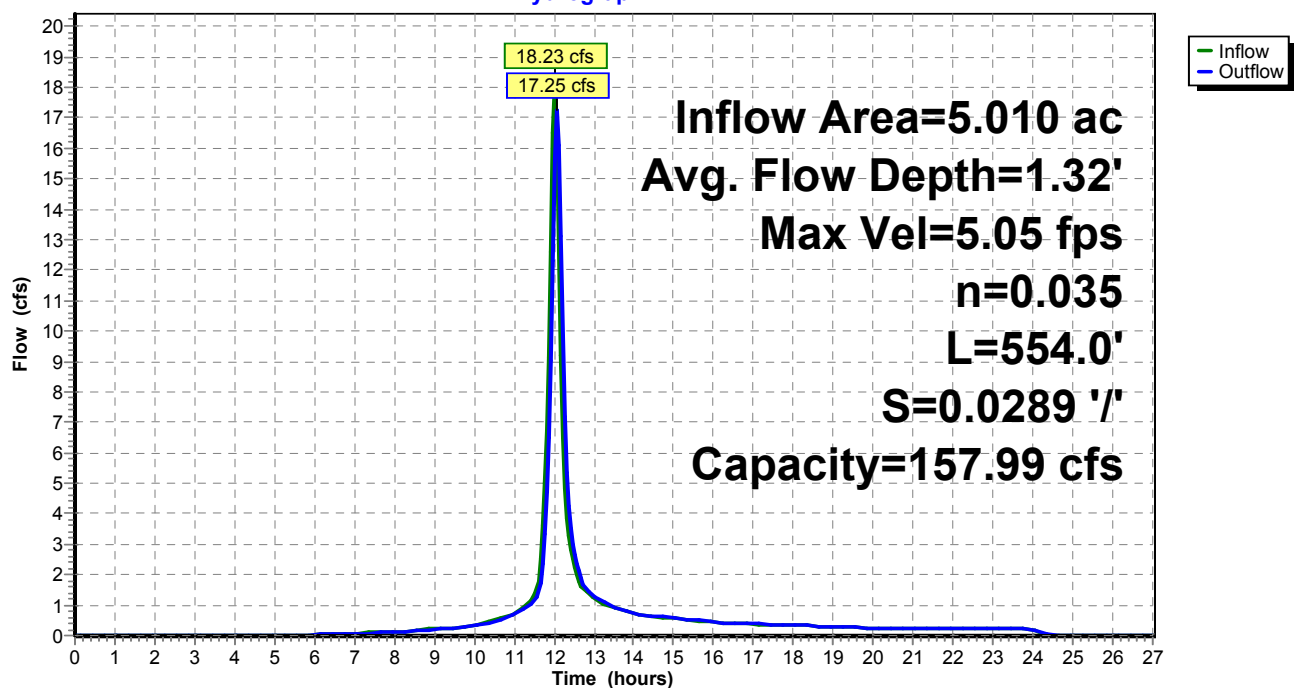
Length= 554.0' Slope= 0.0289 ' '

Inlet Invert= 4,795.00', Outlet Invert= 4,779.00'



Reach 2R: WS 11 Swale

Hydrograph



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Summary for Reach 3R: WS 6 Channel

Inflow Area = 14.790 ac, 10.01% Impervious, Inflow Depth = 2.93" for 100-YR event
Inflow = 69.08 cfs @ 11.97 hrs, Volume= 3.606 af
Outflow = 64.68 cfs @ 12.01 hrs, Volume= 3.606 af, Atten= 6%, Lag= 2.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Max. Velocity= 6.42 fps, Min. Travel Time= 1.4 min

Avg. Velocity = 1.63 fps, Avg. Travel Time= 5.6 min

Peak Storage= 5,746 cf @ 11.99 hrs

Average Depth at Peak Storage= 1.50'

Bank-Full Depth= 3.00' Flow Area= 30.0 sf, Capacity= 281.64 cfs

4.00' x 3.00' deep channel, n= 0.035

Side Slope Z-value= 2.0 ' Top Width= 16.00'

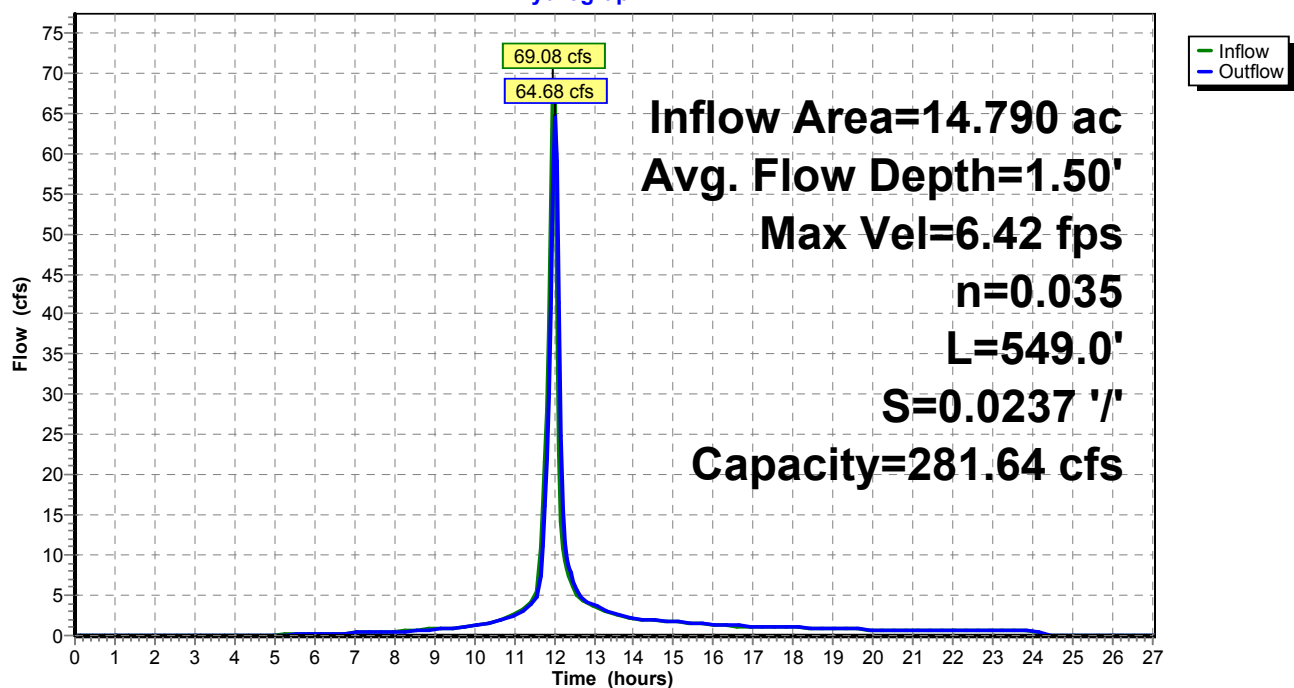
Length= 549.0' Slope= 0.0237 ' / '

Inlet Invert= 4,788.00', Outlet Invert= 4,775.00'



Reach 3R: WS 6 Channel

Hydrograph



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Summary for Reach 4R: WS 8A Channel

Inflow Area = 29.210 ac, 10.00% Impervious, Inflow Depth = 2.80" for 100-YR event
Inflow = 118.24 cfs @ 12.00 hrs, Volume= 6.821 af
Outflow = 111.10 cfs @ 12.05 hrs, Volume= 6.821 af, Atten= 6%, Lag= 2.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Max. Velocity= 7.32 fps, Min. Travel Time= 1.6 min

Avg. Velocity = 1.85 fps, Avg. Travel Time= 6.4 min

Peak Storage= 11,048 cf @ 12.02 hrs

Average Depth at Peak Storage= 1.80'

Bank-Full Depth= 3.00' Flow Area= 33.0 sf, Capacity= 319.17 cfs

5.00' x 3.00' deep channel, n= 0.035

Side Slope Z-value= 2.0 ' / ' Top Width= 17.00'

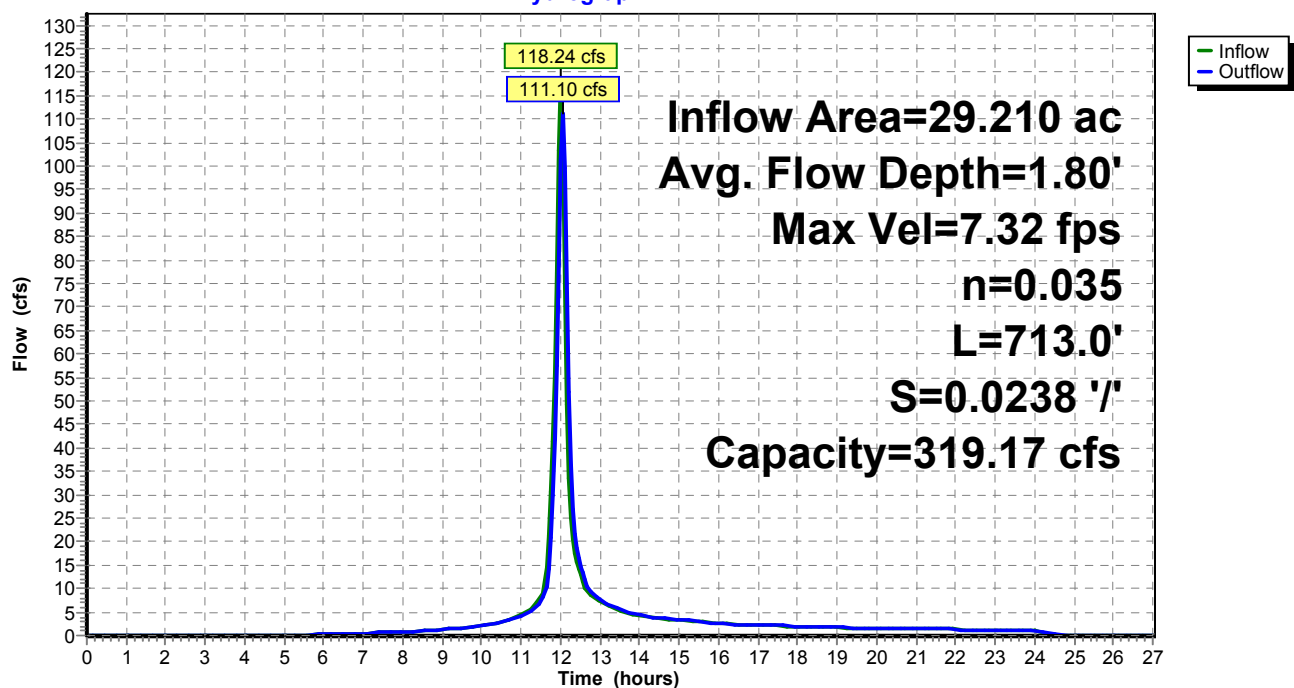
Length= 713.0' Slope= 0.0238 ' / '

Inlet Invert= 4,767.00', Outlet Invert= 4,750.00'



Reach 4R: WS 8A Channel

Hydrograph



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Summary for Reach 5R: WS 10 Channel

Inflow Area = 36.330 ac, 9.99% Impervious, Inflow Depth = 2.80" for 100-YR event
Inflow = 135.54 cfs @ 12.05 hrs, Volume= 8.491 af
Outflow = 131.64 cfs @ 12.07 hrs, Volume= 8.491 af, Atten= 3%, Lag= 0.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Max. Velocity= 6.74 fps, Min. Travel Time= 0.6 min

Avg. Velocity = 1.78 fps, Avg. Travel Time= 2.2 min

Peak Storage= 4,737 cf @ 12.06 hrs

Average Depth at Peak Storage= 2.14'

Bank-Full Depth= 3.00' Flow Area= 33.0 sf, Capacity= 267.40 cfs

5.00' x 3.00' deep channel, n= 0.035

Side Slope Z-value= 2.0 ' / ' Top Width= 17.00'

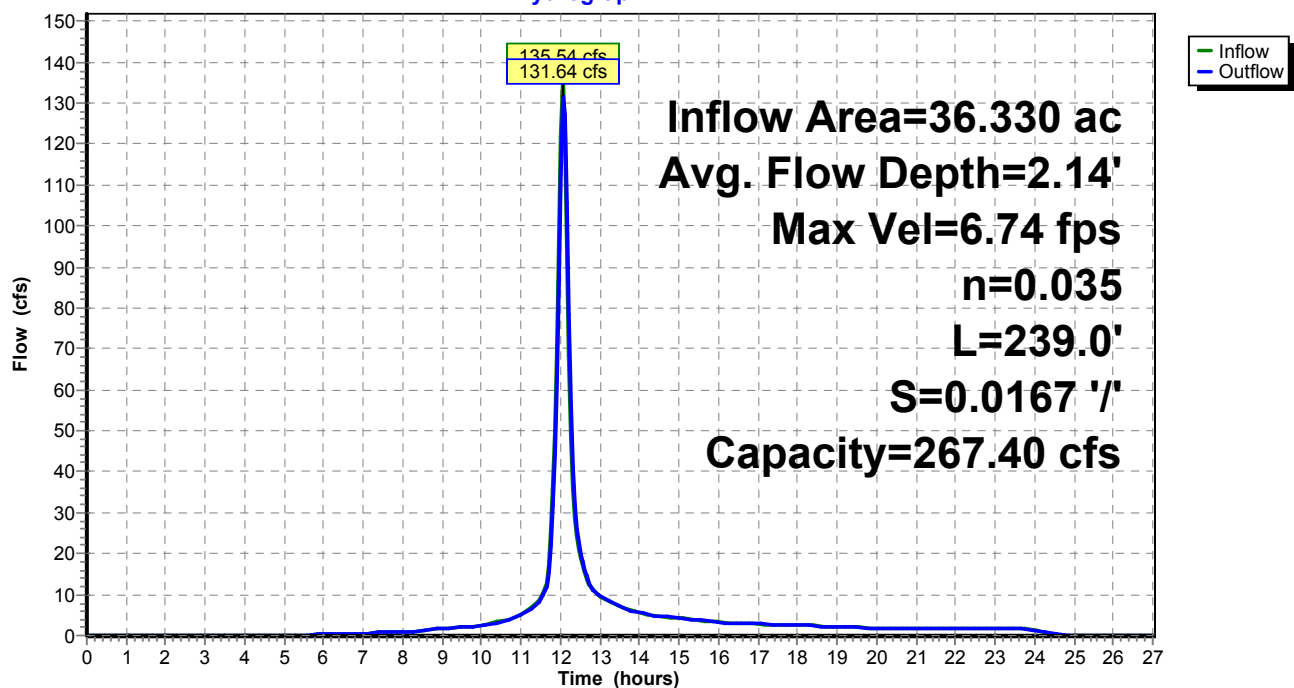
Length= 239.0' Slope= 0.0167 ' / '

Inlet Invert= 4,750.00', Outlet Invert= 4,746.00'



Reach 5R: WS 10 Channel

Hydrograph



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Summary for Pond 3P: Storm Water Pond

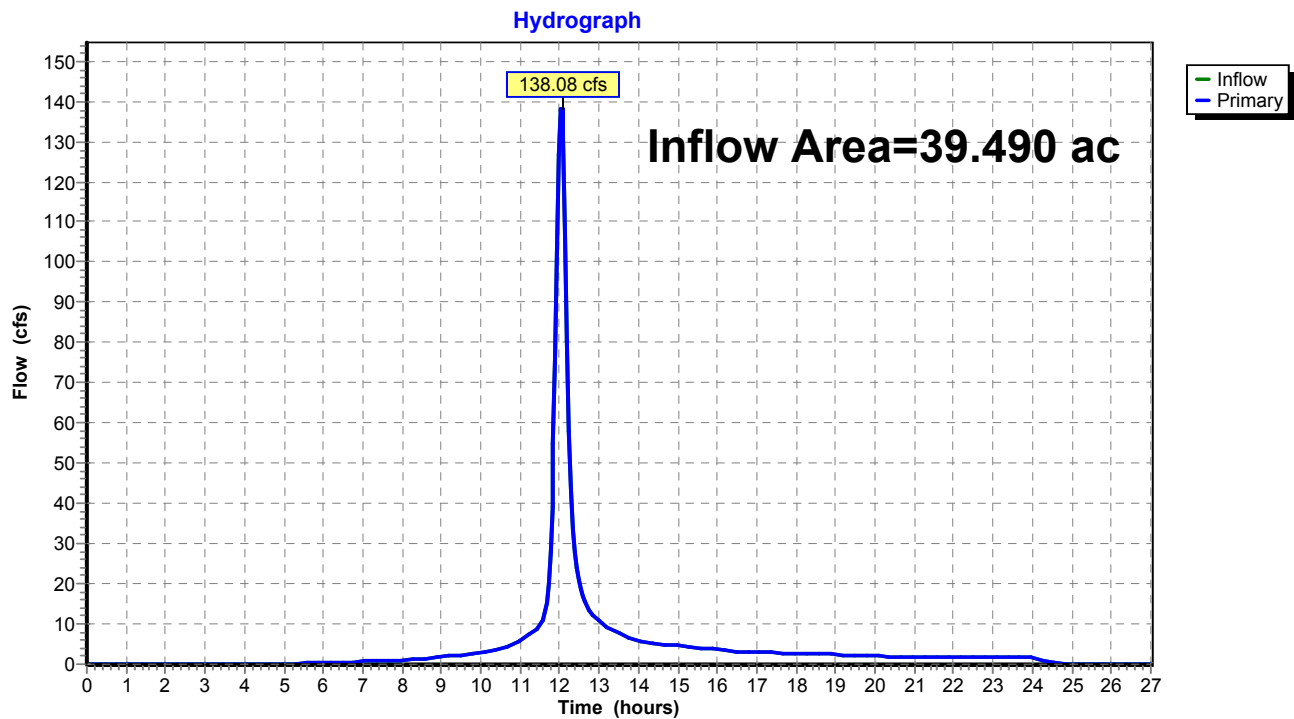
Inflow Area = 39.490 ac, 13.19% Impervious, Inflow Depth = 2.85" for 100-YR event

Inflow = 138.08 cfs @ 12.06 hrs, Volume= 9.366 af

Primary = 138.08 cfs @ 12.06 hrs, Volume= 9.366 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

Pond 3P: Storm Water Pond



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Summary for Pond CLVT1: Culvert #1

Inflow Area = 11.500 ac, 10.00% Impervious, Inflow Depth = 3.01" for 100-YR event
Inflow = 55.18 cfs @ 11.98 hrs, Volume= 2.886 af
Outflow = 55.18 cfs @ 11.98 hrs, Volume= 2.886 af, Atten= 0%, Lag= 0.0 min
Primary = 55.18 cfs @ 11.98 hrs, Volume= 2.886 af

Routing by Stor-Ind method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

Peak Elev= 4,802.86' @ 11.98 hrs

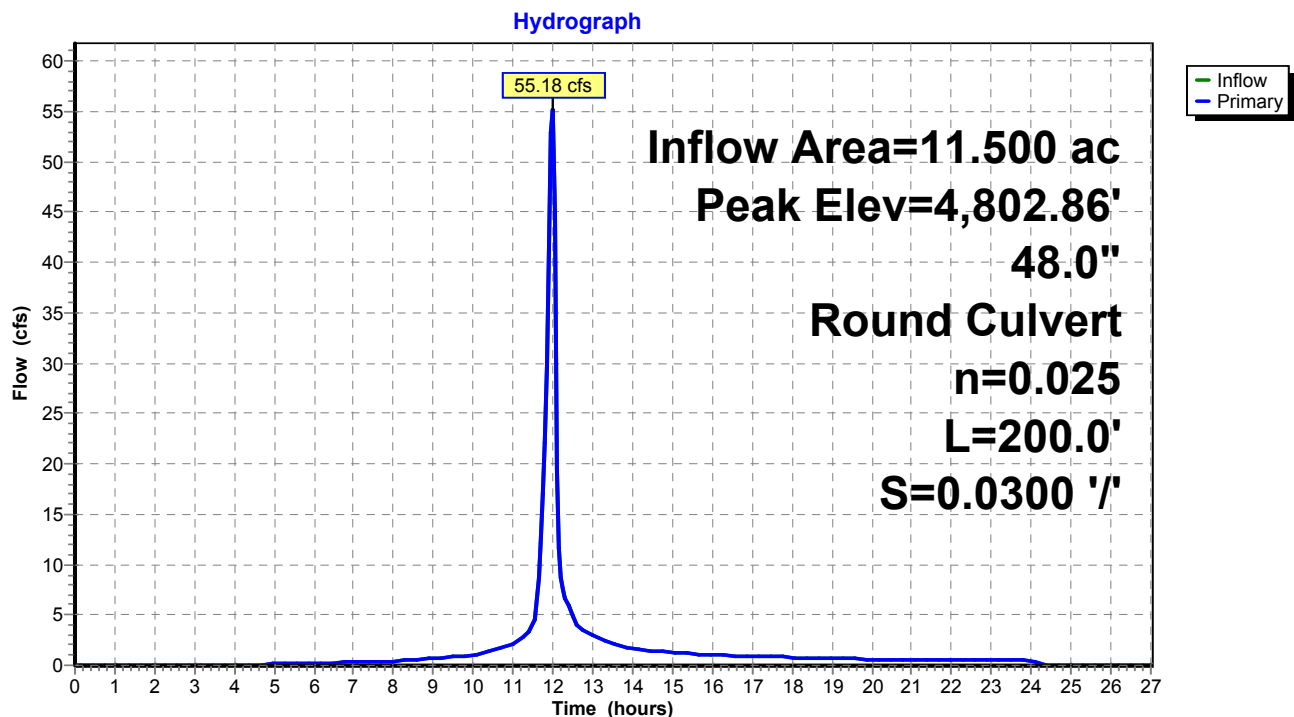
Flood Elev= 4,805.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	4,800.00'	48.0" Round Culvert L= 200.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 4,800.00' / 4,794.00' S= 0.0300 '/ Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 12.57 sf

Primary OutFlow Max=53.07 cfs @ 11.98 hrs HW=4,802.78' (Free Discharge)

↑1=Culvert (Inlet Controls 53.07 cfs @ 5.68 fps)

Pond CLVT1: Culvert #1



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Summary for Pond CLVT2: Culvert #2

Inflow Area = 14.790 ac, 10.01% Impervious, Inflow Depth = 2.93" for 100-YR event
Inflow = 64.68 cfs @ 12.01 hrs, Volume= 3.606 af
Outflow = 64.68 cfs @ 12.01 hrs, Volume= 3.606 af, Atten= 0%, Lag= 0.0 min
Primary = 64.68 cfs @ 12.01 hrs, Volume= 3.606 af

Routing by Stor-Ind method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

Peak Elev= 4,773.17' @ 12.01 hrs

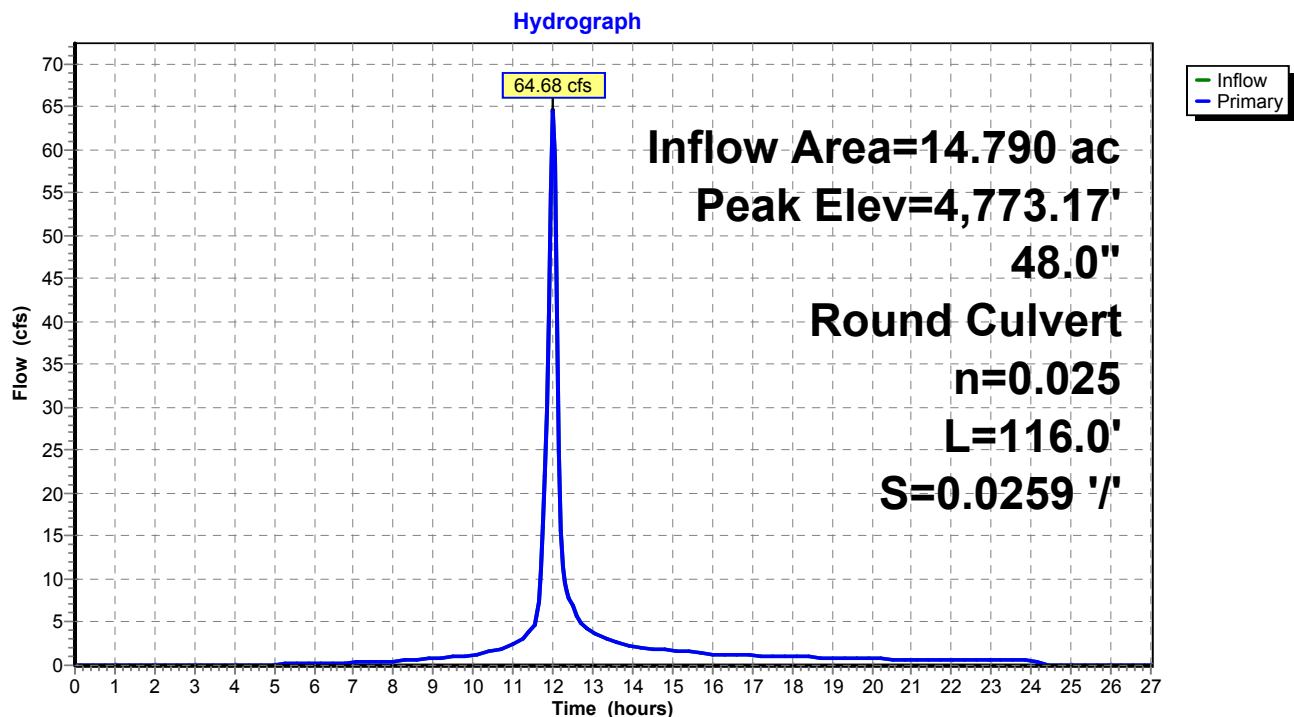
Flood Elev= 4,775.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	4,770.00'	48.0" Round 48" Culvert L= 116.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 4,770.00' / 4,767.00' S= 0.0259 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 12.57 sf

Primary OutFlow Max=63.81 cfs @ 12.01 hrs HW=4,773.14' (Free Discharge)

↑ **1=48" Culvert** (Inlet Controls 63.81 cfs @ 6.03 fps)

Pond CLVT2: Culvert #2



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Summary for Pond CLVT3: Culvert #3

Inflow Area = 5.010 ac, 9.98% Impervious, Inflow Depth = 2.72" for 100-YR event
Inflow = 17.25 cfs @ 12.05 hrs, Volume= 1.137 af
Outflow = 17.25 cfs @ 12.05 hrs, Volume= 1.137 af, Atten= 0%, Lag= 0.0 min
Primary = 17.25 cfs @ 12.05 hrs, Volume= 1.137 af

Routing by Stor-Ind method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

Peak Elev= 4,772.08' @ 12.05 hrs

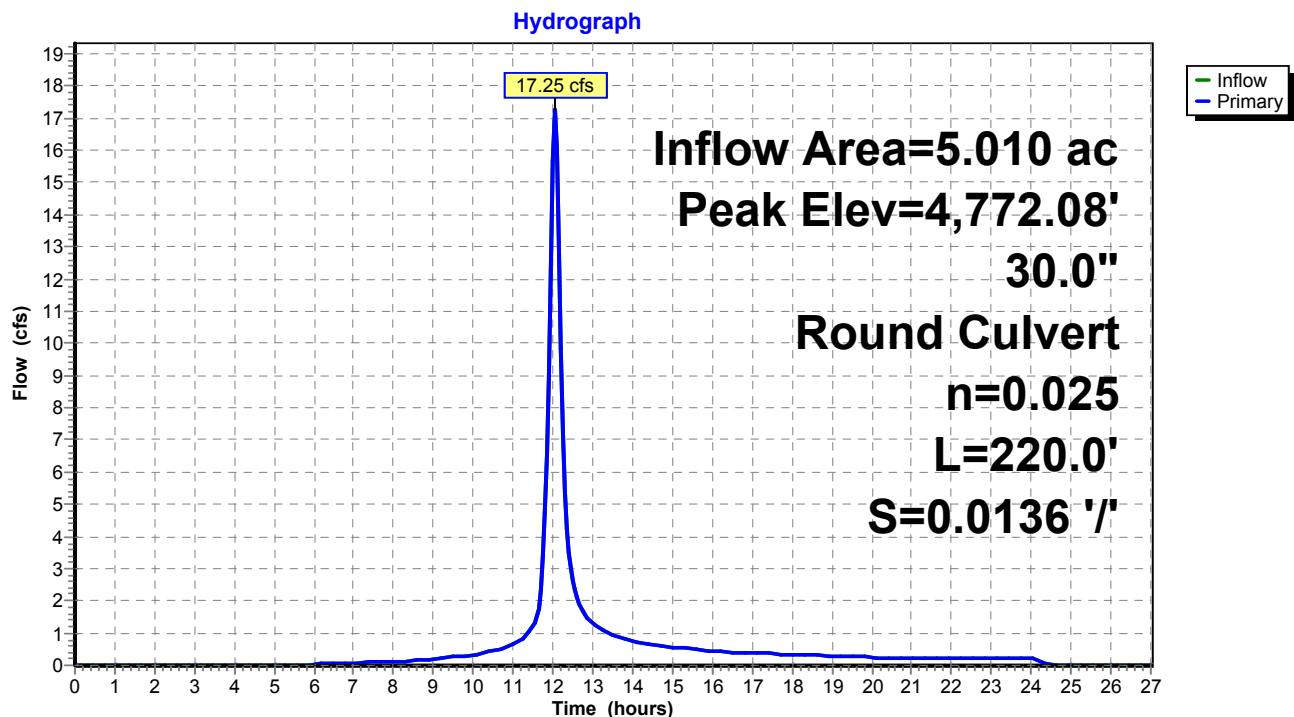
Flood Elev= 4,777.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	4,770.00'	30.0" Round 30" Culvert L= 220.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 4,770.00' / 4,767.00' S= 0.0136 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 4.91 sf

Primary OutFlow Max=17.16 cfs @ 12.05 hrs HW=4,772.07' (Free Discharge)

↑ **1=30" Culvert** (Barrel Controls 17.16 cfs @ 5.35 fps)

Pond CLVT3: Culvert #3



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Summary for Pond CLVT5: Culvert #5

Inflow Area = 2.890 ac, 10.03% Impervious, Inflow Depth = 2.72" for 100-YR event
Inflow = 12.17 cfs @ 12.00 hrs, Volume= 0.655 af
Outflow = 12.17 cfs @ 12.00 hrs, Volume= 0.655 af, Atten= 0%, Lag= 0.0 min
Primary = 12.17 cfs @ 12.00 hrs, Volume= 0.655 af

Routing by Stor-Ind method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

Peak Elev= 4,762.18' @ 12.00 hrs

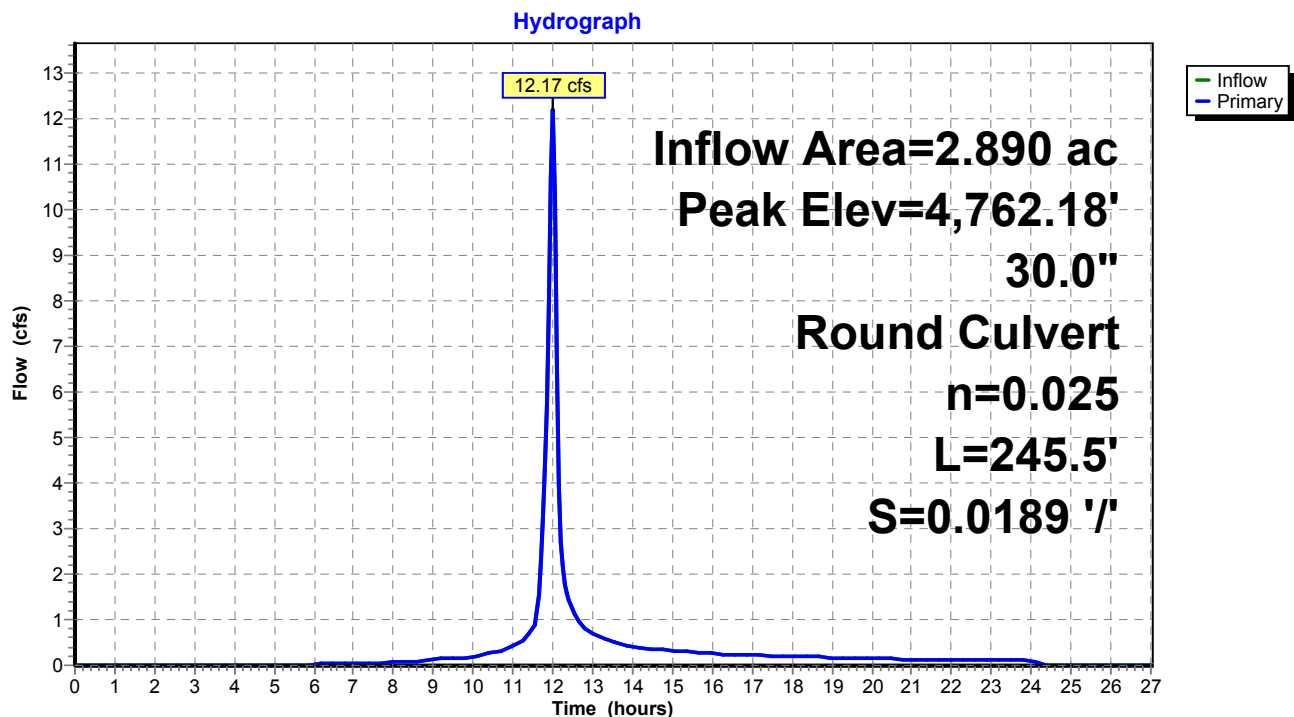
Flood Elev= 4,765.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	4,760.65'	30.0" Round 30" Culvert L= 245.5' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 4,760.65' / 4,756.00' S= 0.0189 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 4.91 sf

Primary OutFlow Max=12.06 cfs @ 12.00 hrs HW=4,762.17' (Free Discharge)

↑ **1=30" Culvert** (Barrel Controls 12.06 cfs @ 5.53 fps)

Pond CLVT5: Culvert #5



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Summary for Link WS 8A: WS 8A Outflow

Inflow Area = 4.100 ac, 10.00% Impervious, Inflow Depth = 2.45" for 100-YR event

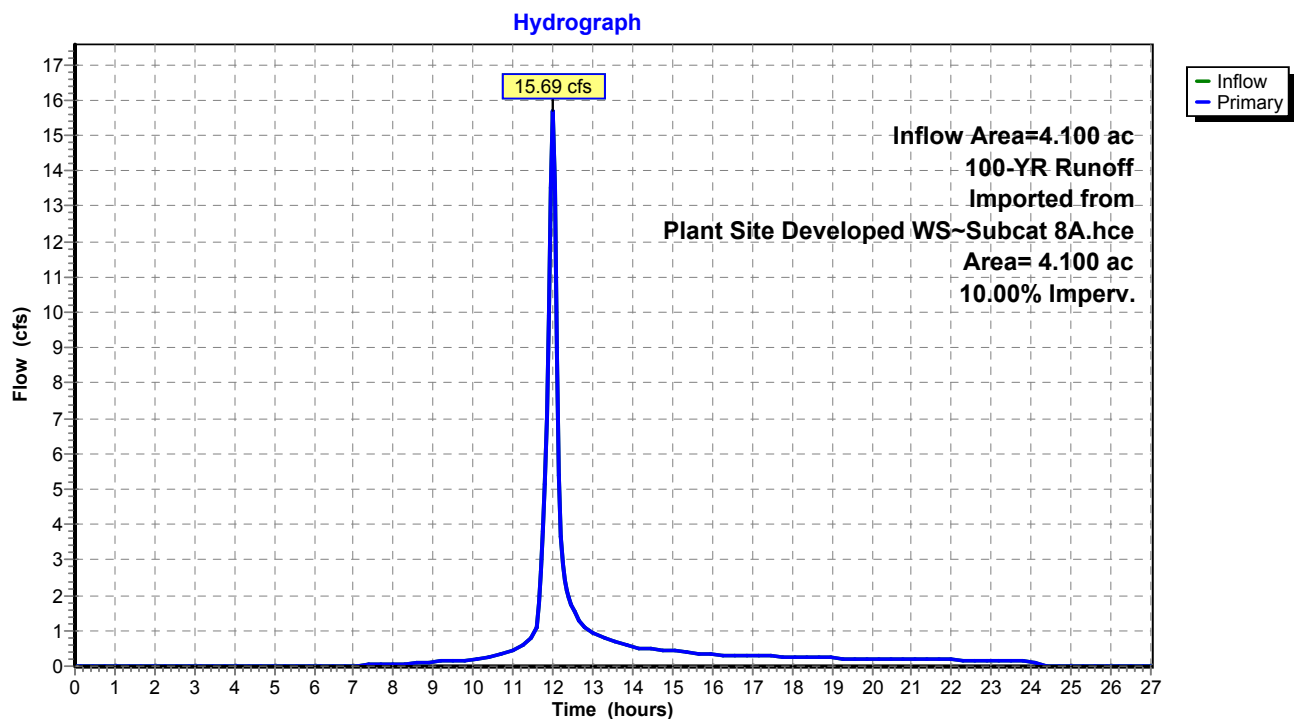
Inflow = 15.69 cfs @ 12.00 hrs, Volume= 0.836 af

Primary = 15.69 cfs @ 12.00 hrs, Volume= 0.836 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 8A.hce

Link WS 8A: WS 8A Outflow



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Summary for Link WS 8B: WS 8B Outflow

Inflow Area = 2.890 ac, 10.03% Impervious, Inflow Depth = 2.72" for 100-YR event

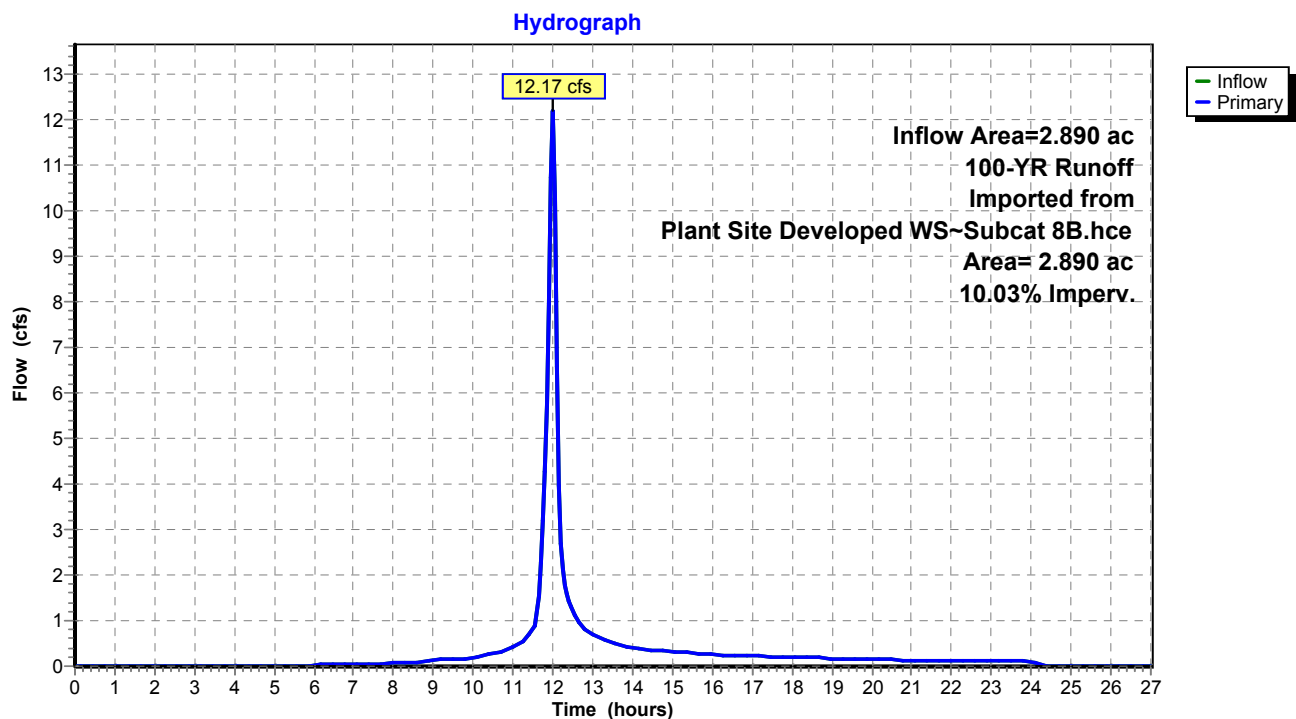
Inflow = 12.17 cfs @ 12.00 hrs, Volume= 0.655 af

Primary = 12.17 cfs @ 12.00 hrs, Volume= 0.655 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 8B.hce

Link WS 8B: WS 8B Outflow



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Summary for Link WS10: WS 10 Outflow

Inflow Area = 3.160 ac, 50.00% Impervious, Inflow Depth = 3.32" for 100-YR event

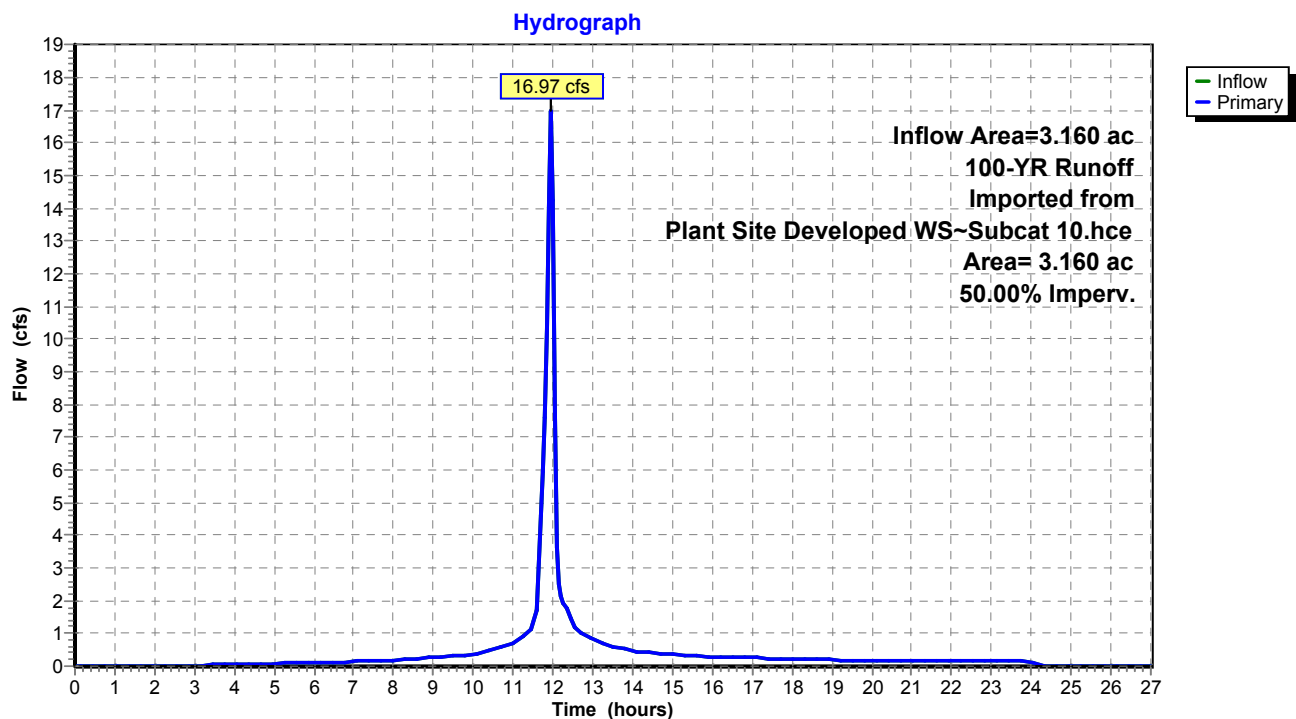
Inflow = 16.97 cfs @ 11.95 hrs, Volume= 0.875 af

Primary = 16.97 cfs @ 11.95 hrs, Volume= 0.875 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 10.hce

Link WS10: WS 10 Outflow



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Summary for Link WS11: WS 11 Outflow

Inflow Area = 3.760 ac, 10.11% Impervious, Inflow Depth = 2.63" for 100-YR event

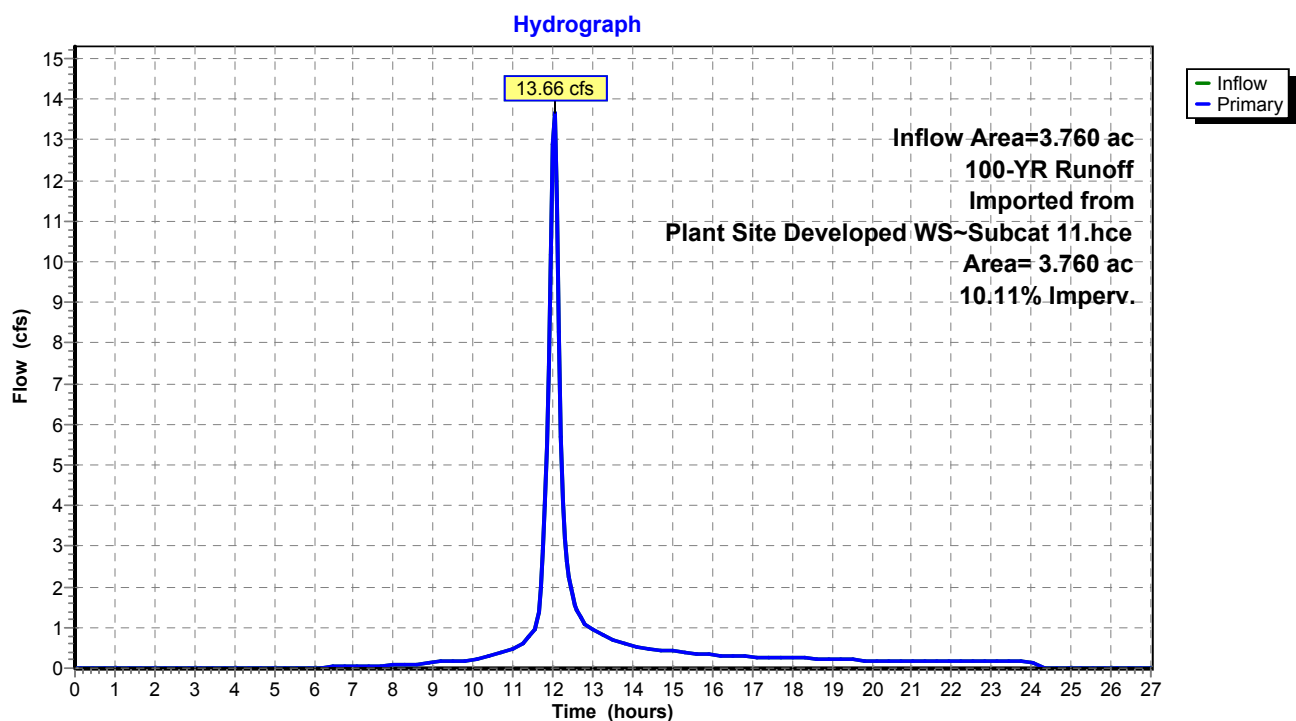
Inflow = 13.66 cfs @ 12.04 hrs, Volume= 0.823 af

Primary = 13.66 cfs @ 12.04 hrs, Volume= 0.823 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 11.hce

Link WS11: WS 11 Outflow



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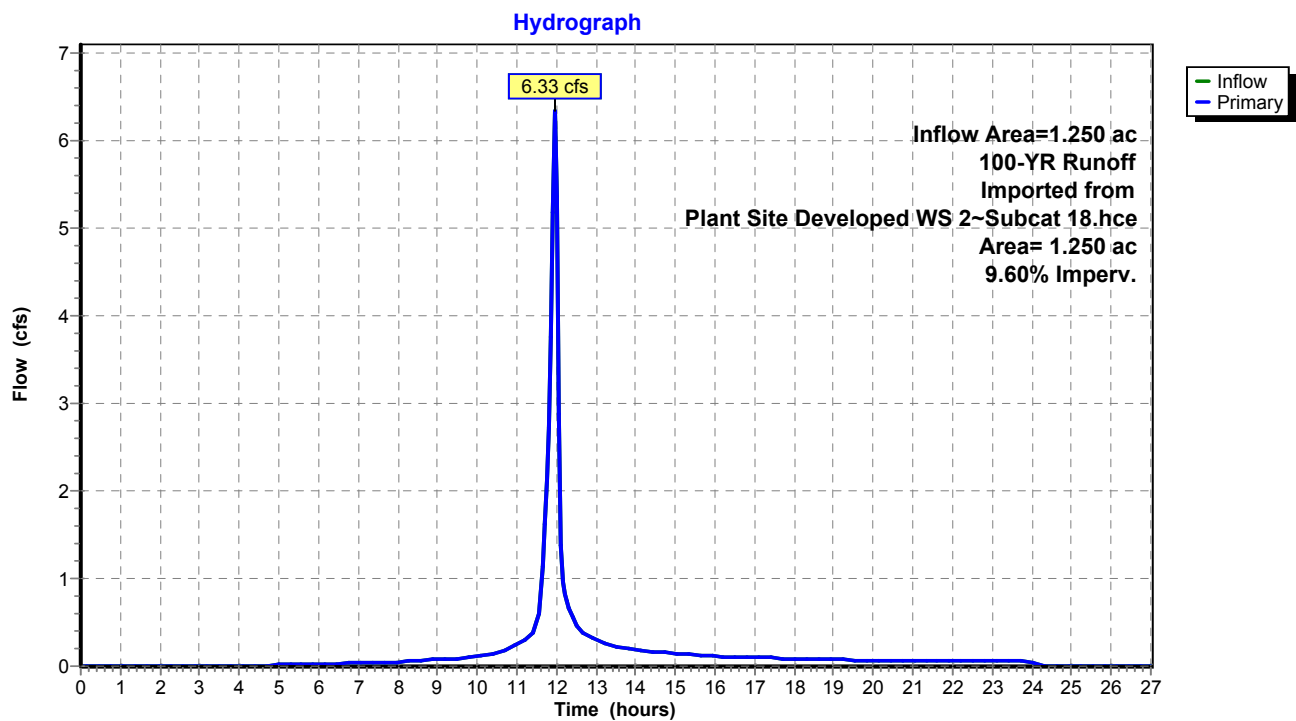
Summary for Link WS18: WS 18 Outflow

Inflow Area = 1.250 ac, 9.60% Impervious, Inflow Depth = 3.01" for 100-YR event
Inflow = 6.33 cfs @ 11.95 hrs, Volume= 0.314 af
Primary = 6.33 cfs @ 11.95 hrs, Volume= 0.314 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 18.hce

Link WS18: WS 18 Outflow



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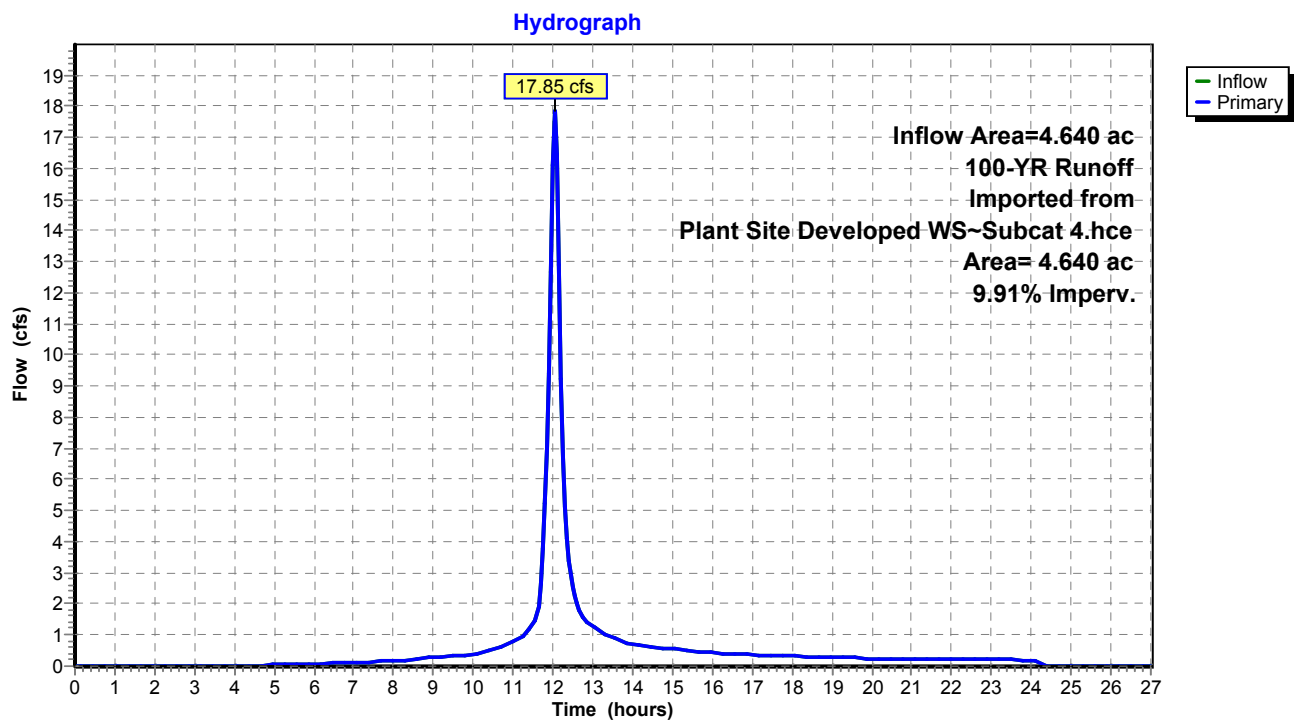
Summary for Link WS4: WS 4 Outflow

Inflow Area = 4.640 ac, 9.91% Impervious, Inflow Depth = 3.01" for 100-YR event
Inflow = 17.85 cfs @ 12.05 hrs, Volume= 1.164 af
Primary = 17.85 cfs @ 12.05 hrs, Volume= 1.164 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 4.hce

Link WS4: WS 4 Outflow



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Summary for Link WS5: WS 5 Outflow

Inflow Area = 11.500 ac, 10.00% Impervious, Inflow Depth = 3.01" for 100-YR event

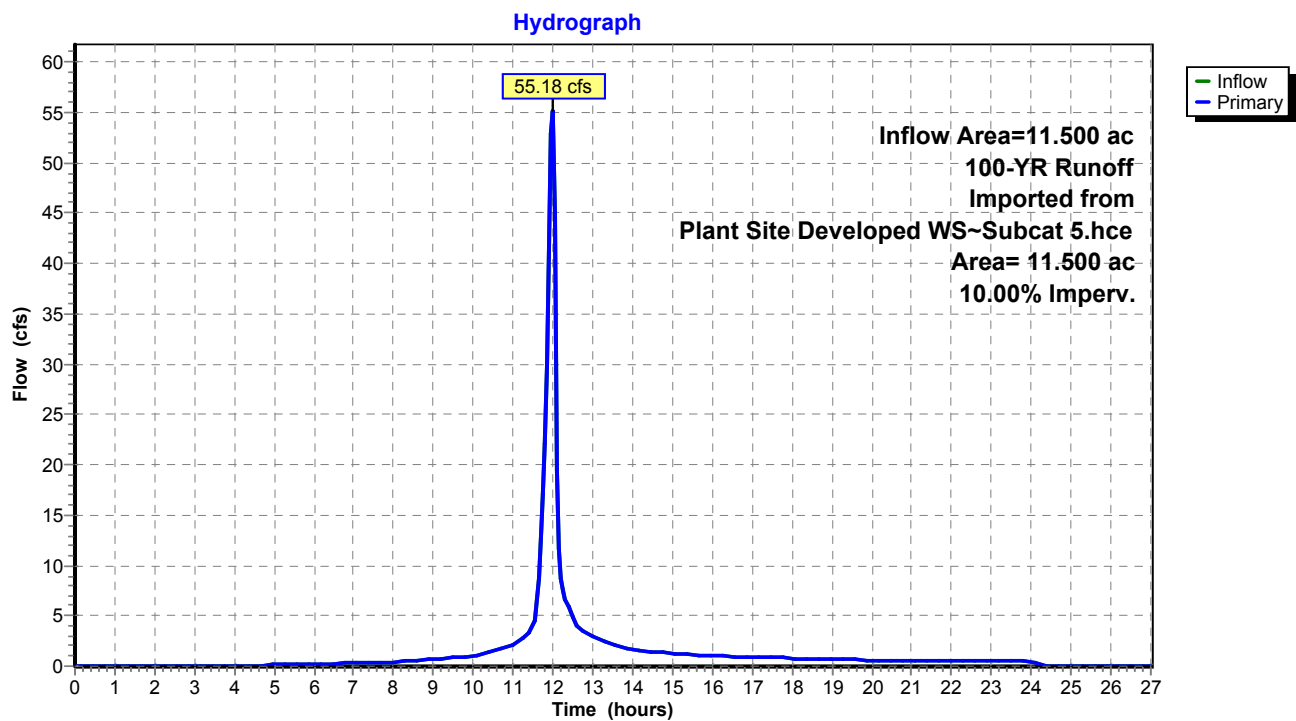
Inflow = 55.18 cfs @ 11.98 hrs, Volume= 2.886 af

Primary = 55.18 cfs @ 11.98 hrs, Volume= 2.886 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 5.hce

Link WS5: WS 5 Outflow



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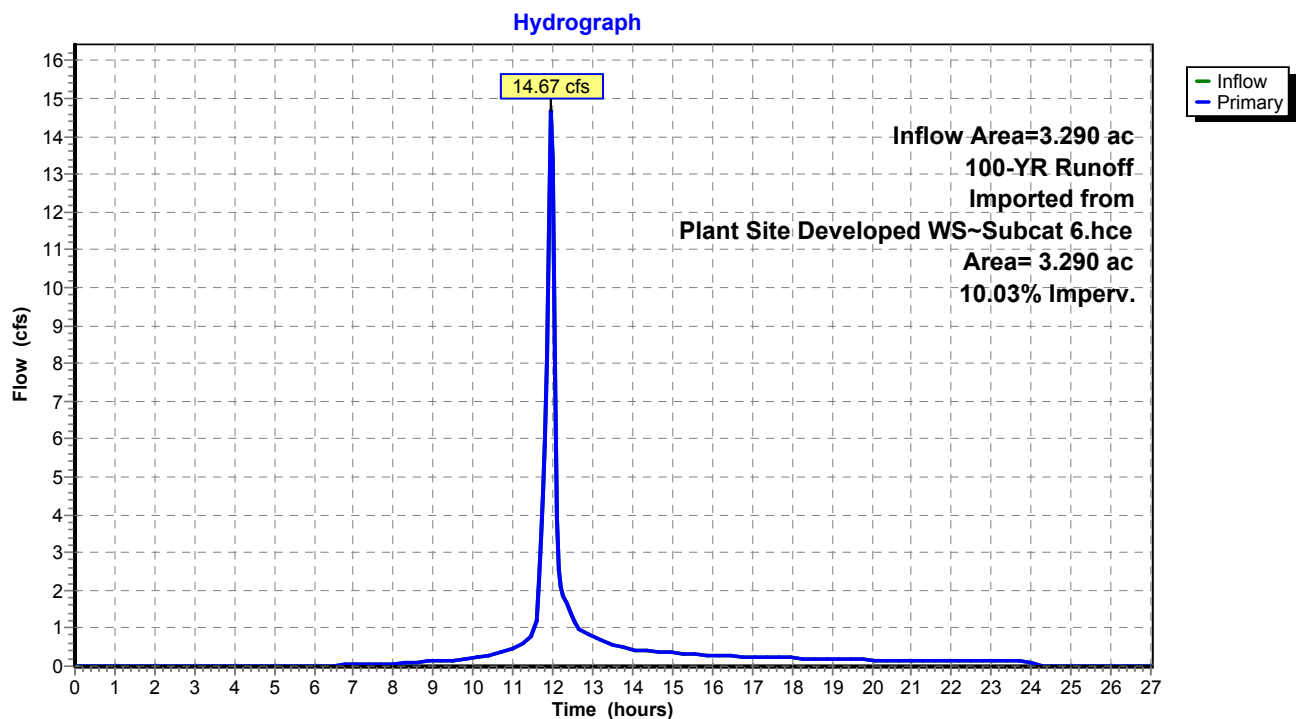
Summary for Link WS6: WS 6 Outflow

Inflow Area = 3.290 ac, 10.03% Impervious, Inflow Depth = 2.63" for 100-YR event
Inflow = 14.67 cfs @ 11.96 hrs, Volume= 0.720 af
Primary = 14.67 cfs @ 11.96 hrs, Volume= 0.720 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 6.hce

Link WS6: WS 6 Outflow



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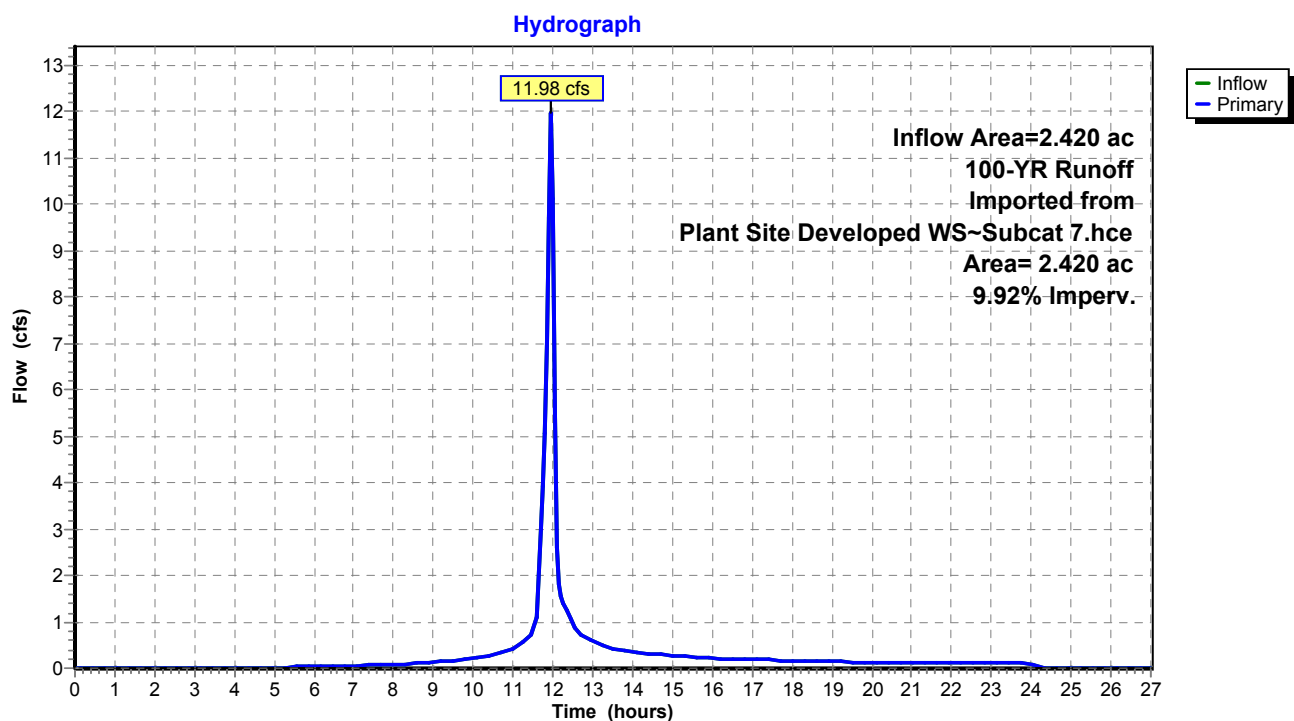
Summary for Link WS7: WS 7 Outflow

Inflow Area = 2.420 ac, 9.92% Impervious, Inflow Depth = 2.91" for 100-YR event
Inflow = 11.98 cfs @ 11.95 hrs, Volume= 0.587 af
Primary = 11.98 cfs @ 11.95 hrs, Volume= 0.587 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 7.hce

Link WS7: WS 7 Outflow



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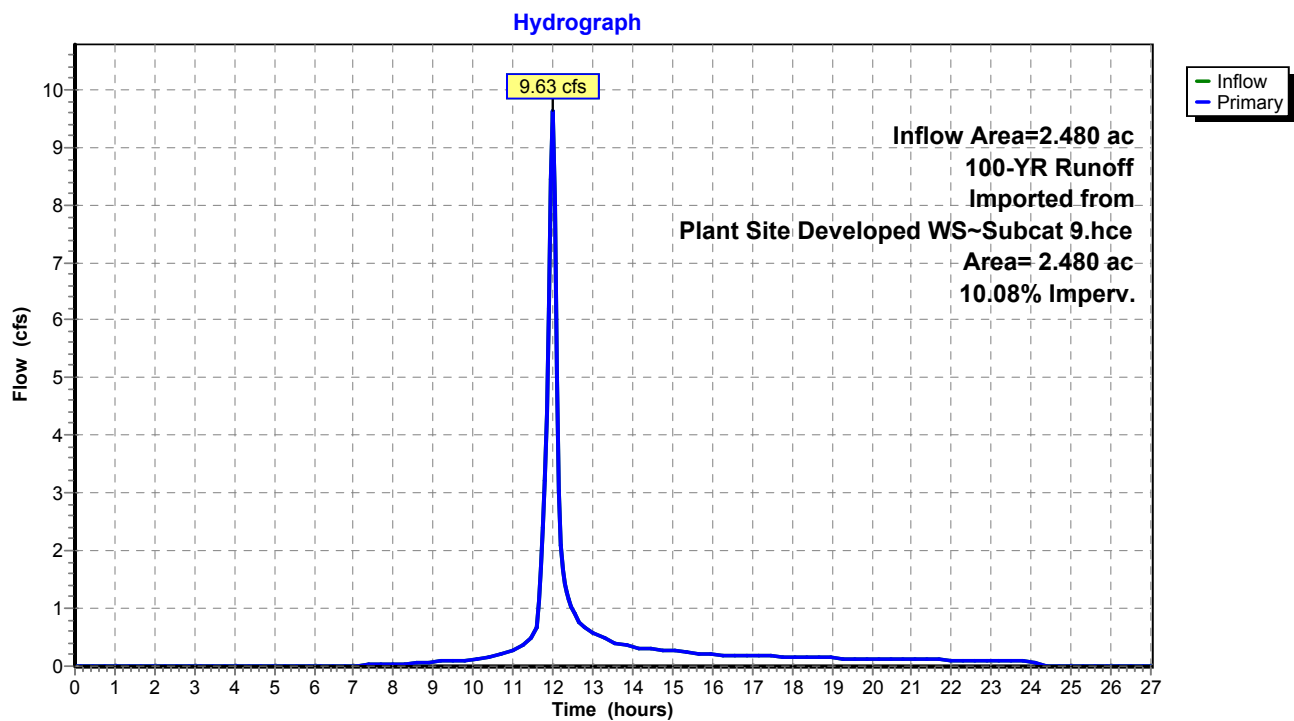
Summary for Link WS9: WS 9 Outflow

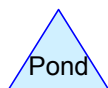
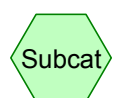
Inflow Area = 2.480 ac, 10.08% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 9.63 cfs @ 12.00 hrs, Volume= 0.506 af
Primary = 9.63 cfs @ 12.00 hrs, Volume= 0.506 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 9.hce

Link WS9: WS 9 Outflow





Routing Diagram for Plant Site Flow Routing 2

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Plant Site Flow Routing 2

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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.000	0	TOTAL AREA

Plant Site Flow Routing 2

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Time span=0.00-27.00 hrs, dt=0.05 hrs, 541 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Reach 2R: WS 15 Diversion Channel Avg. Flow Depth=1.48' Max Vel=5.79 fps Inflow=55.51 cfs 4.537 af
n=0.035 L=1,667.0' S=0.0208 '/' Capacity=230.61 cfs Outflow=50.82 cfs 4.536 af

Reach 3R: WS 17 Diversion Channel Avg. Flow Depth=2.46' Max Vel=6.66 fps Inflow=165.57 cfs 22.323 af
n=0.035 L=1,645.0' S=0.0141 '/' Capacity=452.62 cfs Outflow=161.77 cfs 22.300 af

Reach 6R: WS 19 Swale Avg. Flow Depth=0.88' Max Vel=3.42 fps Inflow=5.65 cfs 0.267 af
n=0.035 L=290.0' S=0.0228 '/' Capacity=47.57 cfs Outflow=5.18 cfs 0.267 af

Reach WS14R: WS 14 Reach Avg. Flow Depth=0.59' Max Vel=4.68 fps Inflow=192.93 cfs 20.338 af
n=0.030 L=3,874.0' S=0.0217 '/' Capacity=9,740.15 cfs Outflow=162.12 cfs 20.300 af

Pond 1P: WS 1 Ponded Volume Peak Elev=4,734.36' Storage=59,511 cf Inflow=25.45 cfs 1.366 af
Outflow=0.00 cfs 0.000 af

Pond 2P: WS 2 Ponded Volume Peak Elev=4,739.89' Storage=19,719 cf Inflow=9.57 cfs 0.453 af
Outflow=0.00 cfs 0.000 af

Pond 3P: WS 3B Ponded Volume Peak Elev=4,782.22' Storage=7,283 cf Inflow=3.51 cfs 0.167 af
Outflow=0.00 cfs 0.000 af

Pond 4P: WS 16 Ponded Volume Peak Elev=0.00' Storage=0 cf

Pond 5P: CLVT 4 Peak Elev=4,771.20' Inflow=137.01 cfs 10.285 af
48.0" Round Culvert x 2.00 n=0.025 L=152.0' S=0.0316 '/' Outflow=137.01 cfs 10.285 af

Link 100-YR Runoff Imported from Plant Site Developed WS 2~Subcat OFF 1.hce Inflow=111.25 cfs 8.164 af
Area= 40.040 ac 9.99% Imperv. Primary=111.25 cfs 8.164 af

Link 100-YR Runoff Imported from Plant Site Developed WS 2~Subcat OFF 2.hce Inflow=137.01 cfs 10.285 af
Area= 10.400 ac 10.00% Imperv. Primary=137.01 cfs 10.285 af

Link WS1: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 1.hce Inflow=25.45 cfs 1.366 af
Area= 6.700 ac 10.00% Imperv. Primary=25.45 cfs 1.366 af

Link 100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 14.hce Inflow=192.93 cfs 20.338 af
Area= 99.740 ac 10.00% Imperv. Primary=192.93 cfs 20.338 af

Link 100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 15.hce Inflow=37.01 cfs 2.948 af
Area= 13.950 ac 10.04% Imperv. Primary=37.01 cfs 2.948 af

Link 100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 16.hce Inflow=28.10 cfs 1.589 af
Area= 6.330 ac 9.95% Imperv. Primary=28.10 cfs 1.589 af

Link 100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 17.hce Inflow=31.58 cfs 2.022 af
Area= 9.570 ac 10.03% Imperv. Primary=31.58 cfs 2.022 af

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Link 100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 19.hce Inflow=5.65 cfs 0.267 af
Area= 1.310 ac 9.92% Imperv. Primary=5.65 cfs 0.267 af

Link WS2A: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 2A.hce Inflow=9.57 cfs 0.453 af
Area= 2.220 ac 9.91% Imperv. Primary=9.57 cfs 0.453 af

Link WS3B: 100-YR Runoff Imported from Plant Site Developed WS~Subcat 3B.hce Inflow=3.51 cfs 0.167 af
Area= 0.820 ac 9.76% Imperv. Primary=3.51 cfs 0.167 af

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Summary for Reach 2R: WS 15 Diversion Channel

Inflow Area = 20.280 ac, 10.01% Impervious, Inflow Depth = 2.68" for 100-YR event
Inflow = 55.51 cfs @ 12.05 hrs, Volume= 4.537 af
Outflow = 50.82 cfs @ 12.20 hrs, Volume= 4.536 af, Atten= 8%, Lag= 8.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Max. Velocity= 5.79 fps, Min. Travel Time= 4.8 min

Avg. Velocity = 1.75 fps, Avg. Travel Time= 15.9 min

Peak Storage= 14,775 cf @ 12.11 hrs

Average Depth at Peak Storage= 1.48'

Bank-Full Depth= 3.00' Flow Area= 27.0 sf, Capacity= 230.61 cfs

3.00' x 3.00' deep channel, n= 0.035

Side Slope Z-value= 2.0 '/' Top Width= 15.00'

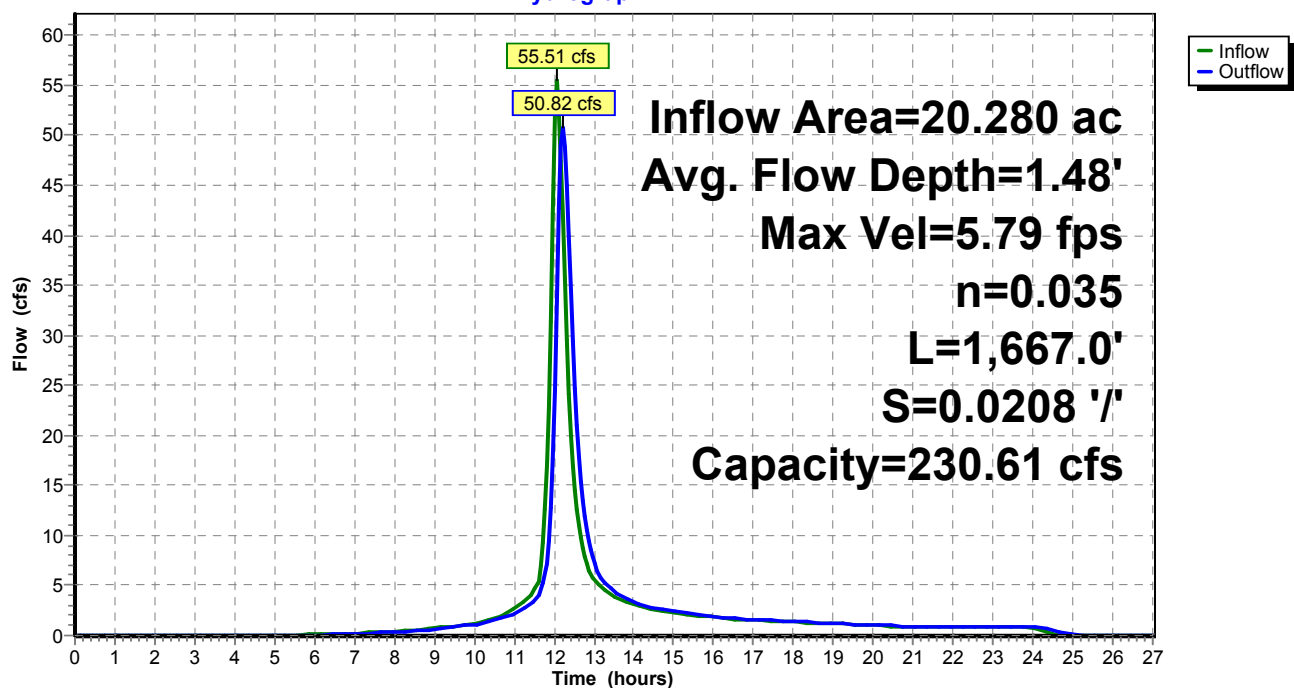
Length= 1,667.0' Slope= 0.0208 '/'

Inlet Invert= 4,784.50', Outlet Invert= 4,749.75'



Reach 2R: WS 15 Diversion Channel

Hydrograph



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Summary for Reach 3R: WS 17 Diversion Channel

Inflow Area = 109.310 ac, 10.00% Impervious, Inflow Depth > 2.45" for 100-YR event
Inflow = 165.57 cfs @ 12.67 hrs, Volume= 22.323 af
Outflow = 161.77 cfs @ 12.80 hrs, Volume= 22.300 af, Atten= 2%, Lag= 7.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Max. Velocity= 6.66 fps, Min. Travel Time= 4.1 min

Avg. Velocity = 2.47 fps, Avg. Travel Time= 11.1 min

Peak Storage= 40,044 cf @ 12.73 hrs

Average Depth at Peak Storage= 2.46'

Bank-Full Depth= 4.00' Flow Area= 52.0 sf, Capacity= 452.62 cfs

5.00' x 4.00' deep channel, n= 0.035

Side Slope Z-value= 2.0 ' / ' Top Width= 21.00'

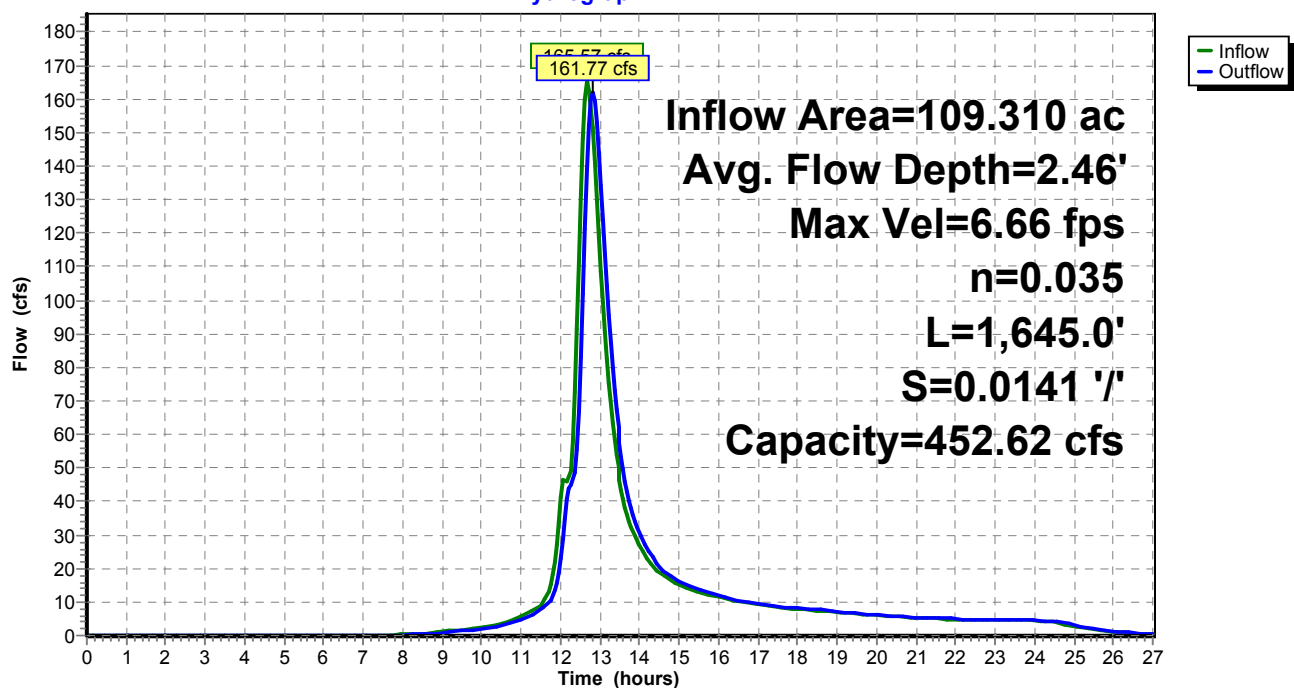
Length= 1,645.0' Slope= 0.0141 ' / '

Inlet Invert= 4,771.80', Outlet Invert= 4,748.65'



Reach 3R: WS 17 Diversion Channel

Hydrograph



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Summary for Reach 6R: WS 19 Swale

Inflow Area = 1.310 ac, 9.92% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 5.65 cfs @ 11.95 hrs, Volume= 0.267 af
Outflow = 5.18 cfs @ 11.99 hrs, Volume= 0.267 af, Atten= 8%, Lag= 2.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Max. Velocity= 3.42 fps, Min. Travel Time= 1.4 min

Avg. Velocity = 1.18 fps, Avg. Travel Time= 4.1 min

Peak Storage= 450 cf @ 11.97 hrs

Average Depth at Peak Storage= 0.88'

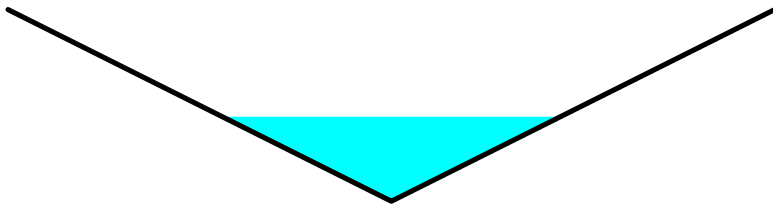
Bank-Full Depth= 2.00' Flow Area= 8.0 sf, Capacity= 47.57 cfs

0.00' x 2.00' deep channel, n= 0.035

Side Slope Z-value= 2.0 '/' Top Width= 8.00'

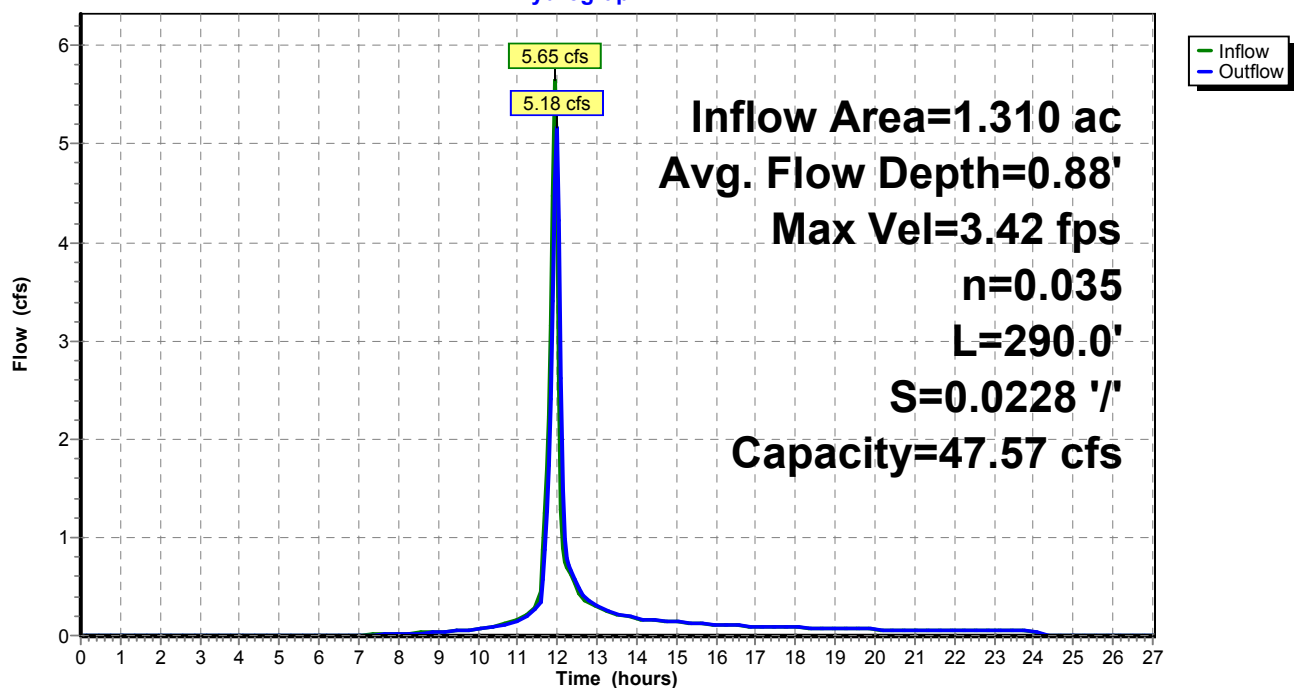
Length= 290.0' Slope= 0.0228 '/'

Inlet Invert= 4,747.00', Outlet Invert= 4,740.40'



Reach 6R: WS 19 Swale

Hydrograph



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Summary for Reach WS14R: WS 14 Reach

Inflow Area = 99.740 ac, 10.00% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 192.93 cfs @ 12.29 hrs, Volume= 20.338 af
Outflow = 162.12 cfs @ 12.68 hrs, Volume= 20.300 af, Atten= 16%, Lag= 22.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Max. Velocity= 4.68 fps, Min. Travel Time= 13.8 min

Avg. Velocity= 1.52 fps, Avg. Travel Time= 42.5 min

Peak Storage= 134,730 cf @ 12.45 hrs

Average Depth at Peak Storage= 0.59'

Bank-Full Depth= 5.00' Flow Area= 625.0 sf, Capacity= 9,740.15 cfs

50.00' x 5.00' deep channel, n= 0.030 Earth, grassed & winding

Side Slope Z-value= 15.0 ' ' Top Width= 200.00'

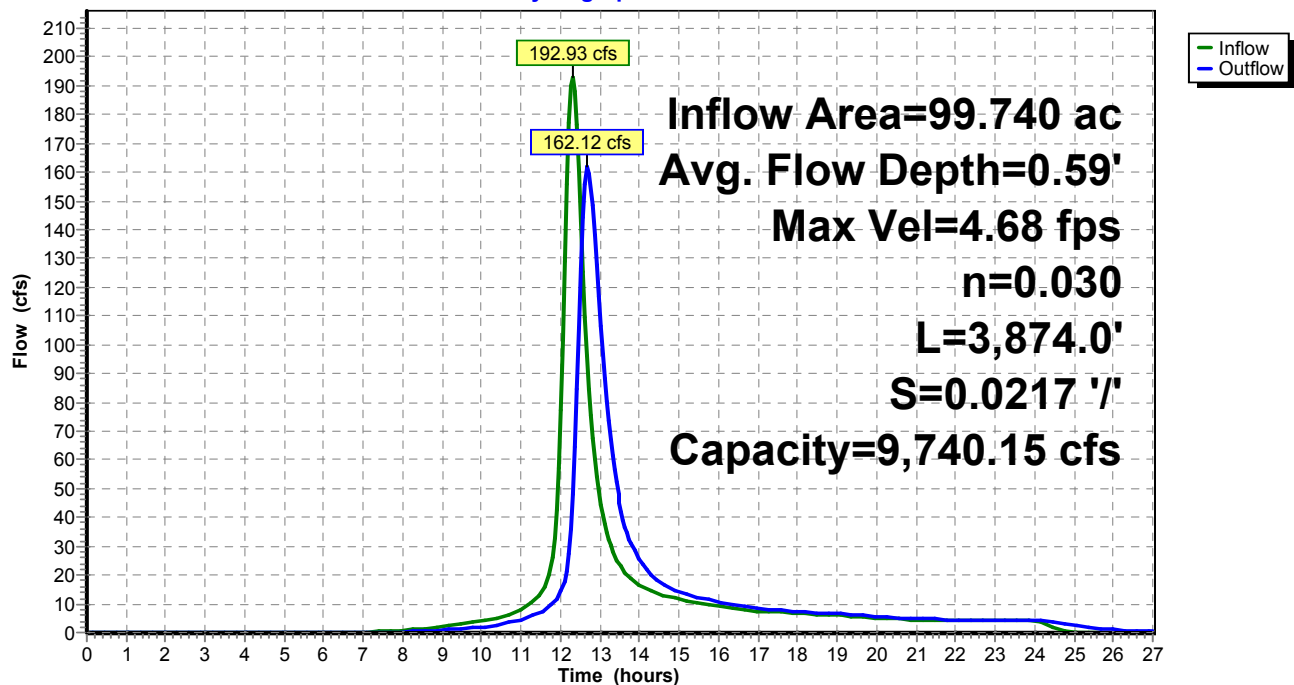
Length= 3,874.0' Slope= 0.0217 ' '

Inlet Invert= 4,856.00', Outlet Invert= 4,771.88'



Reach WS14R: WS 14 Reach

Hydrograph



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Summary for Pond 1P: WS 1 Ponded Volume

Inflow Area = 6.700 ac, 10.00% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 25.45 cfs @ 12.00 hrs, Volume= 1.366 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Peak Elev= 4,734.36' @ 24.55 hrs Surf.Area= 0 sf Storage= 59,511 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	4,730.00'	657,743 cf	Custom Stage Data Listed below

Elevation (feet)	Cum.Store (cubic-feet)
4,730.00	0
4,731.00	2,120
4,732.00	10,119
4,733.00	25,378
4,734.00	48,424
4,735.00	79,426
4,736.00	118,540
4,737.00	166,321
4,738.00	223,396
4,739.00	289,556
4,740.00	364,445
4,741.00	448,469
4,742.00	542,241
4,743.00	657,743

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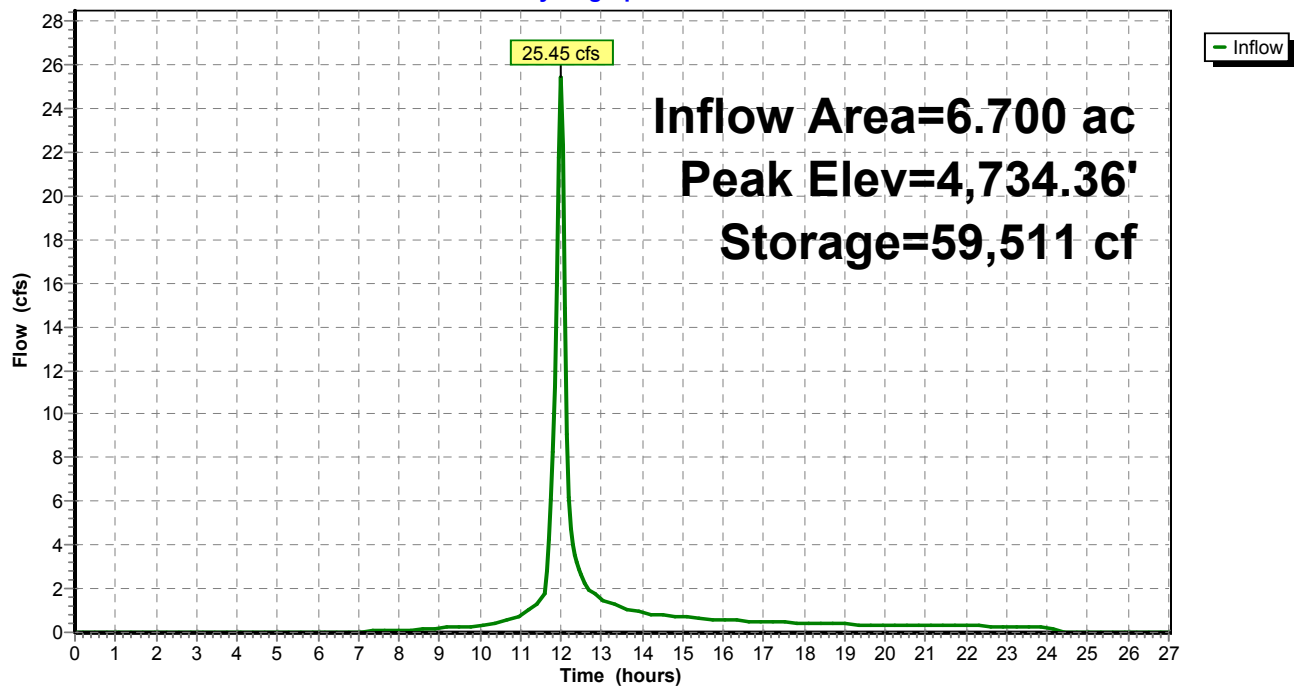
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Pond 1P: WS 1 Poned Volume

Hydrograph



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Summary for Pond 2P: WS 2 Poned Volume

Inflow Area = 2.220 ac, 9.91% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 9.57 cfs @ 11.95 hrs, Volume= 0.453 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

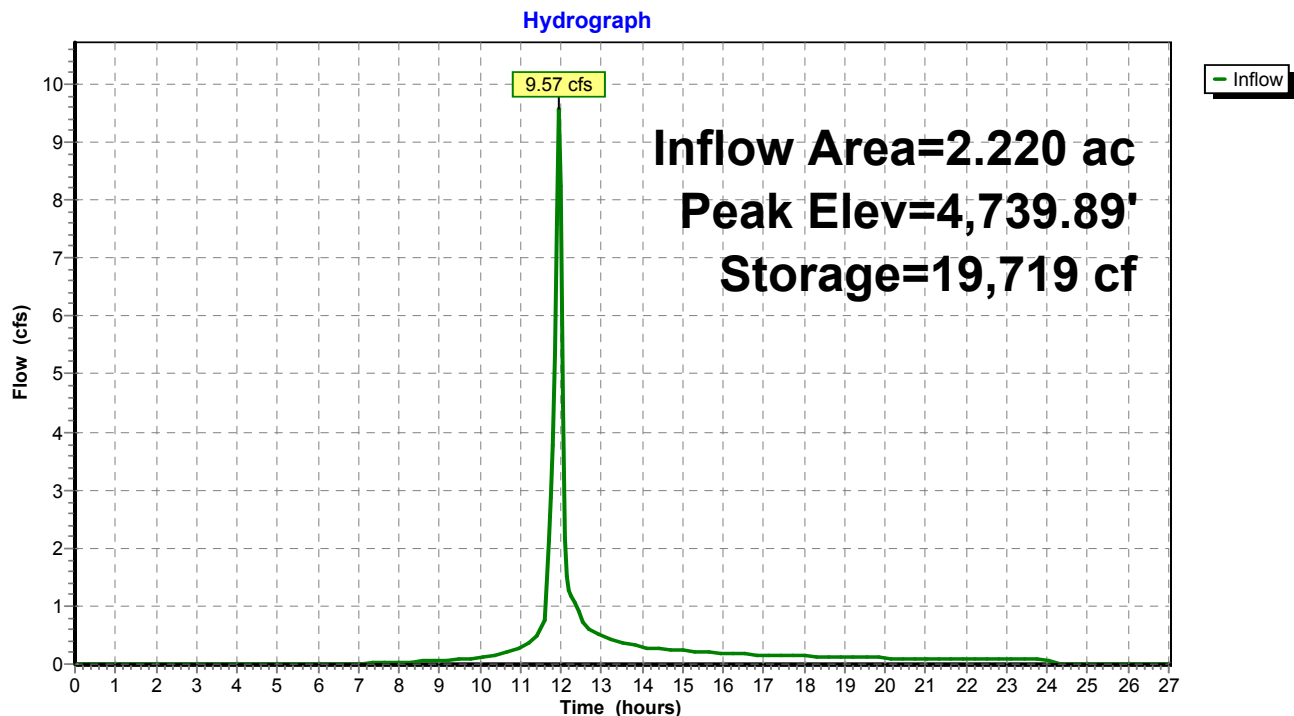
Routing by Stor-Ind method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Peak Elev= 4,739.89' @ 24.35 hrs Surf.Area= 0 sf Storage= 19,719 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	4,736.00'	72,927 cf	Custom Stage Data Listed below

Elevation (feet)	Cum.Store (cubic-feet)
4,736.00	0
4,737.00	1,389
4,738.00	4,924
4,739.00	11,204
4,740.00	20,784
4,741.00	34,000
4,742.00	51,137
4,743.00	72,927

Pond 2P: WS 2 Poned Volume



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Summary for Pond 3P: WS 3B Poned Volume

Inflow Area = 0.820 ac, 9.76% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 3.51 cfs @ 11.96 hrs, Volume= 0.167 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs
Peak Elev= 4,782.22' @ 24.35 hrs Surf.Area= 0 sf Storage= 7,283 cf

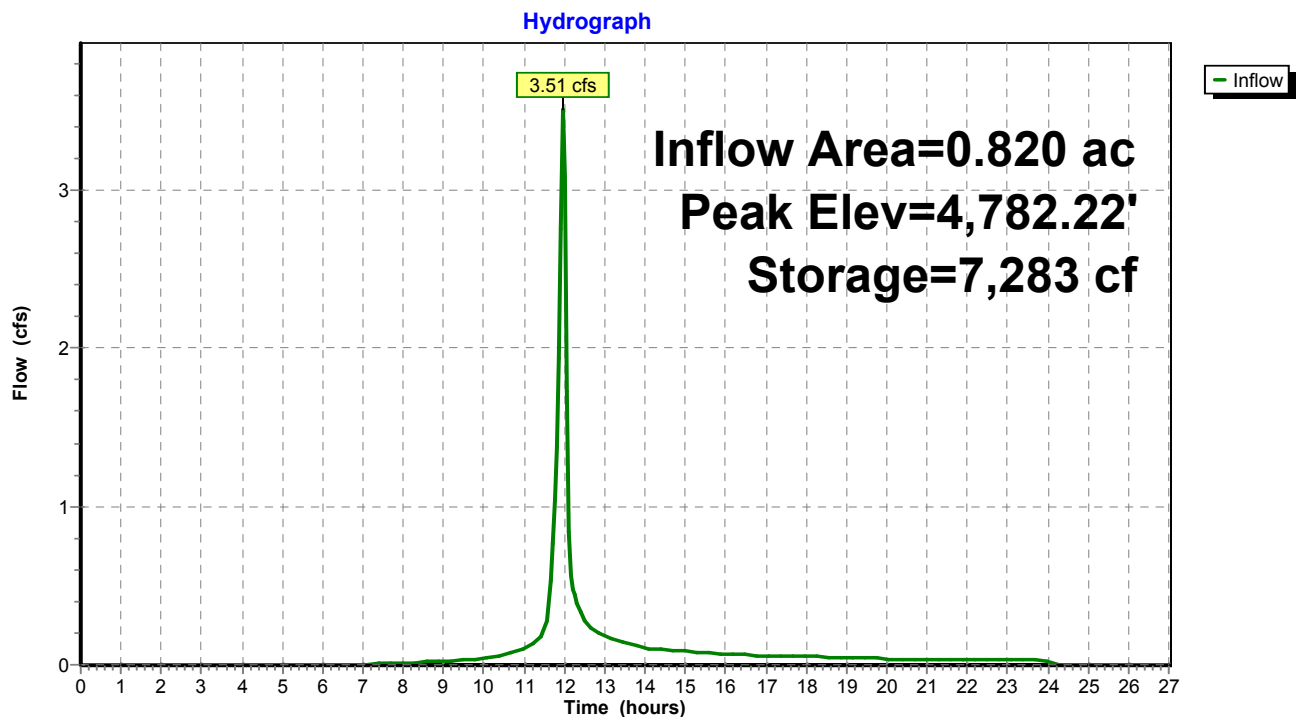
Plug-Flow detention time= (not calculated: initial storage exceeds outflow)

Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	4,779.00'	12,731 cf	Custom Stage Data Listed below

Elevation (feet)	Cum.Store (cubic-feet)
4,779.00	0
4,780.00	284
4,781.00	1,867
4,782.00	5,773
4,783.00	12,731

Pond 3P: WS 3B Poned Volume



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Summary for Pond 4P: WS 16 Poned Volume

Volume	Invert	Avail.Storage	Storage Description
#1	4,754.00'	236,175 cf	Custom Stage Data Listed below
Elevation (feet)	Cum.Store (cubic-feet)		
4,754.00	0		
4,755.00	19,308		
4,756.00	39,659		
4,757.00	60,823		
4,758.00	82,964		
4,759.00	106,747		
4,760.00	133,123		
4,761.00	162,905		
4,762.00	196,934		
4,763.00	236,175		

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Summary for Pond 5P: CLVT 4

Inflow Area = 50.440 ac, 9.99% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 137.01 cfs @ 12.07 hrs, Volume= 10.285 af
Outflow = 137.01 cfs @ 12.07 hrs, Volume= 10.285 af, Atten= 0%, Lag= 0.0 min
Primary = 137.01 cfs @ 12.07 hrs, Volume= 10.285 af

Routing by Stor-Ind method, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs / 2

Peak Elev= 4,771.20' @ 12.07 hrs

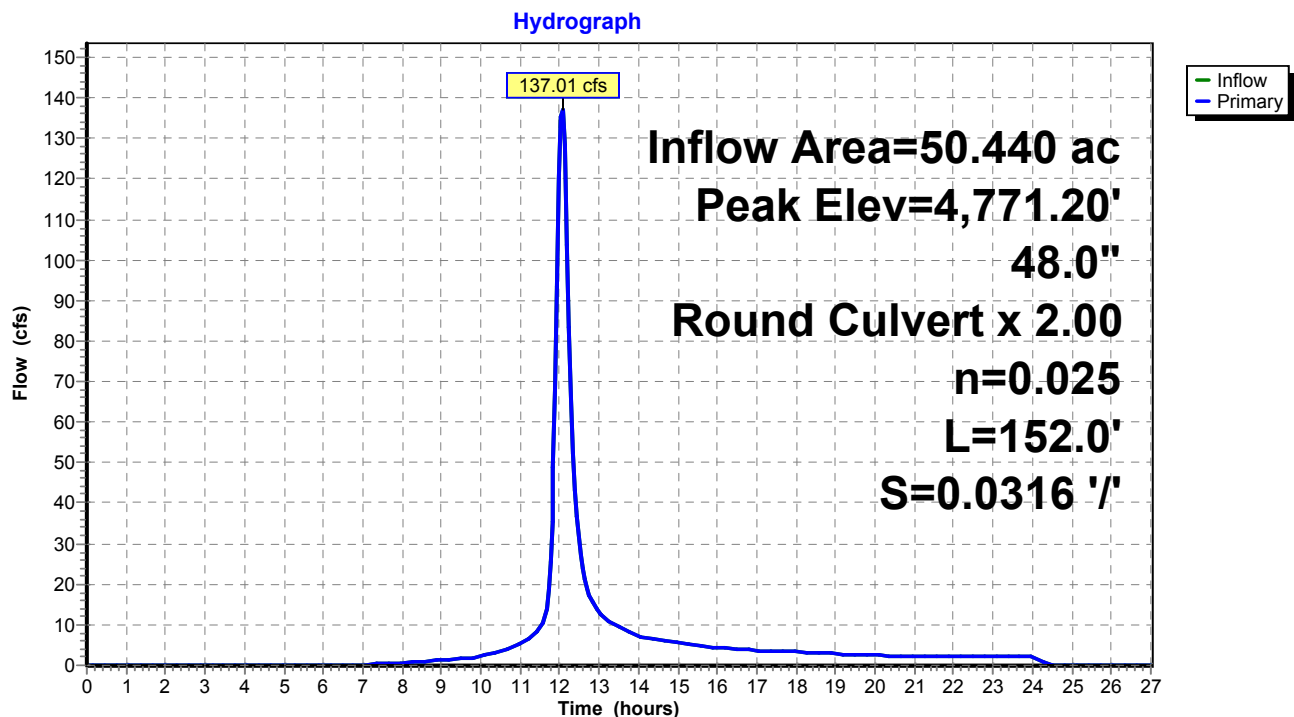
Flood Elev= 4,783.10'

Device	Routing	Invert	Outlet Devices
#1	Primary	4,767.90'	48.0" Round Culvert X 2.00 L= 152.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 4,767.90' / 4,763.10' S= 0.0316 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 12.57 sf

Primary OutFlow Max=135.04 cfs @ 12.07 hrs HW=4,771.16' (Free Discharge)

↑1=Culvert (Inlet Controls 135.04 cfs @ 6.15 fps)

Pond 5P: CLVT 4



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Summary for Link OFF1: OFF1 Outflow

Inflow Area = 40.040 ac, 9.99% Impervious, Inflow Depth = 2.45" for 100-YR event

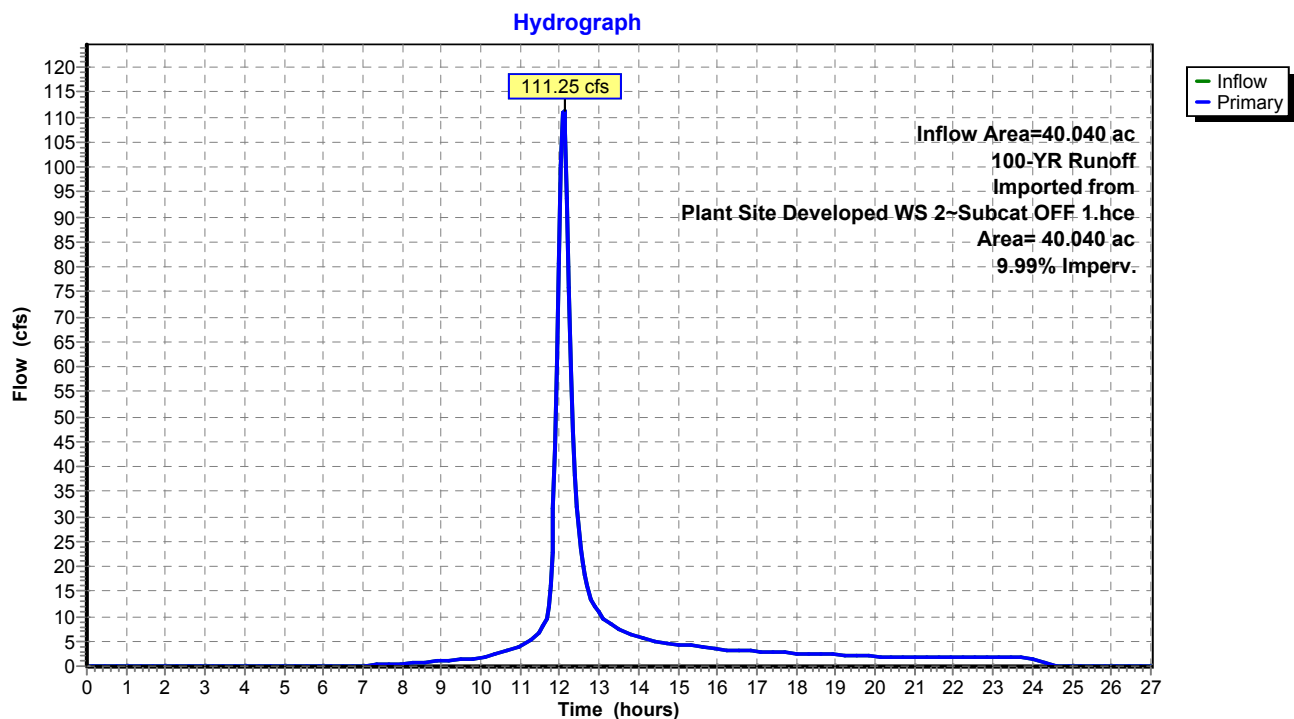
Inflow = 111.25 cfs @ 12.11 hrs, Volume= 8.164 af

Primary = 111.25 cfs @ 12.11 hrs, Volume= 8.164 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS 2~Subcat OFF 1.hce

Link OFF1: OFF1 Outflow



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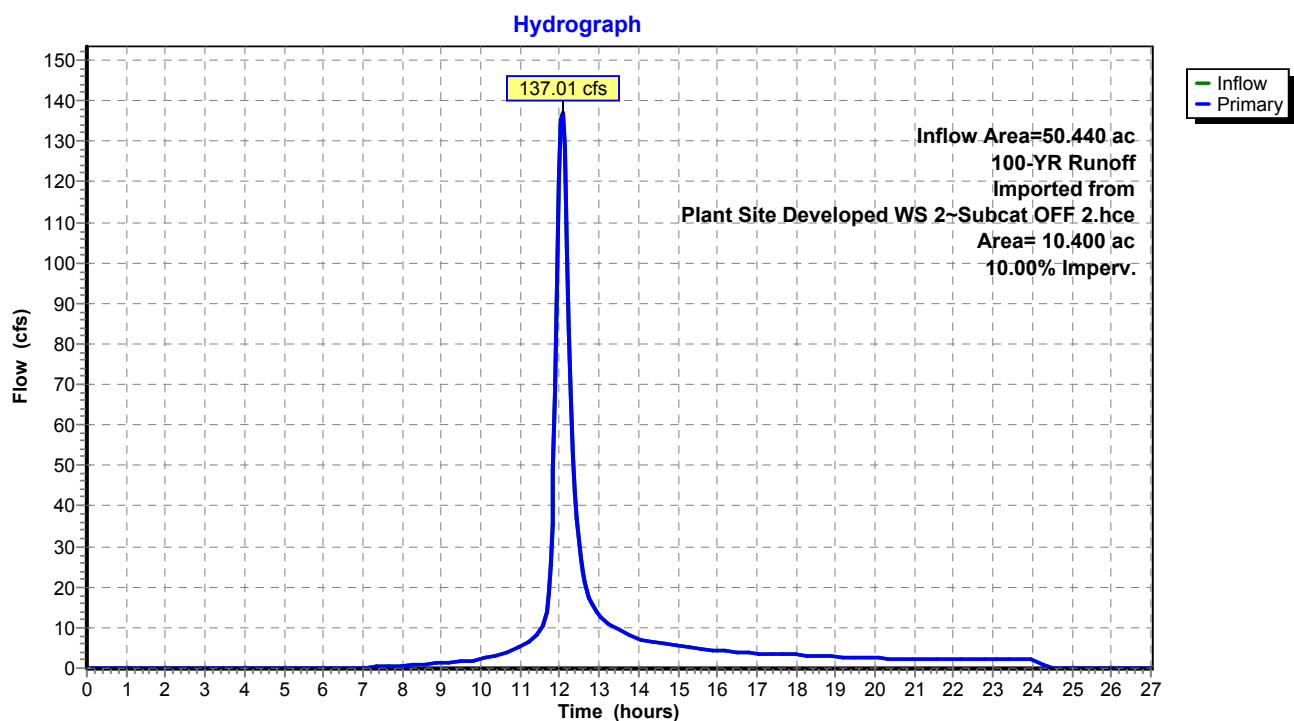
Summary for Link OFF2: OFF2 Outflow

Inflow Area = 50.440 ac, 9.99% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 137.01 cfs @ 12.07 hrs, Volume= 10.285 af
Primary = 137.01 cfs @ 12.07 hrs, Volume= 10.285 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS 2~Subcat OFF 2.hce

Link OFF2: OFF2 Outflow



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Summary for Link WS1: Watershed 1 Outflow

Inflow Area = 6.700 ac, 10.00% Impervious, Inflow Depth = 2.45" for 100-YR event

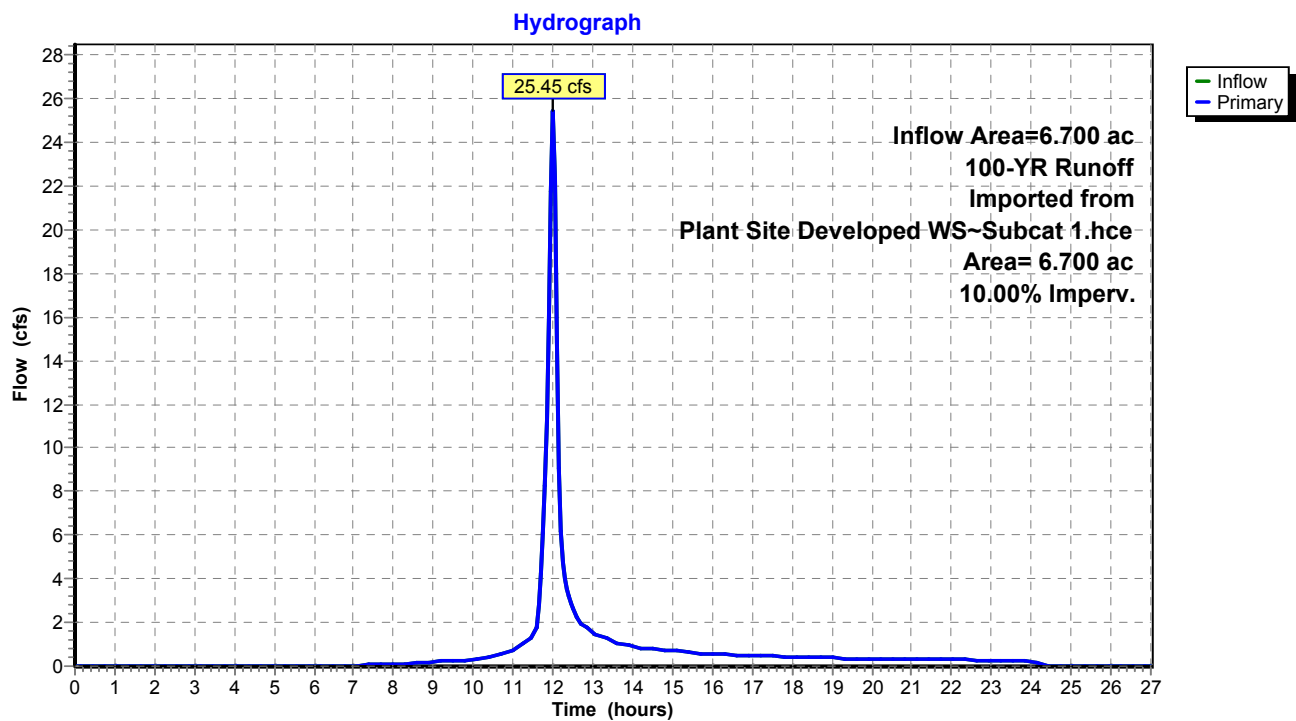
Inflow = 25.45 cfs @ 12.00 hrs, Volume= 1.366 af

Primary = 25.45 cfs @ 12.00 hrs, Volume= 1.366 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 1.hce

Link WS1: Watershed 1 Outflow



Plant Site Flow Routing 2

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Summary for Link WS14: WS 14 Outflow

Inflow Area = 99.740 ac, 10.00% Impervious, Inflow Depth = 2.45" for 100-YR event

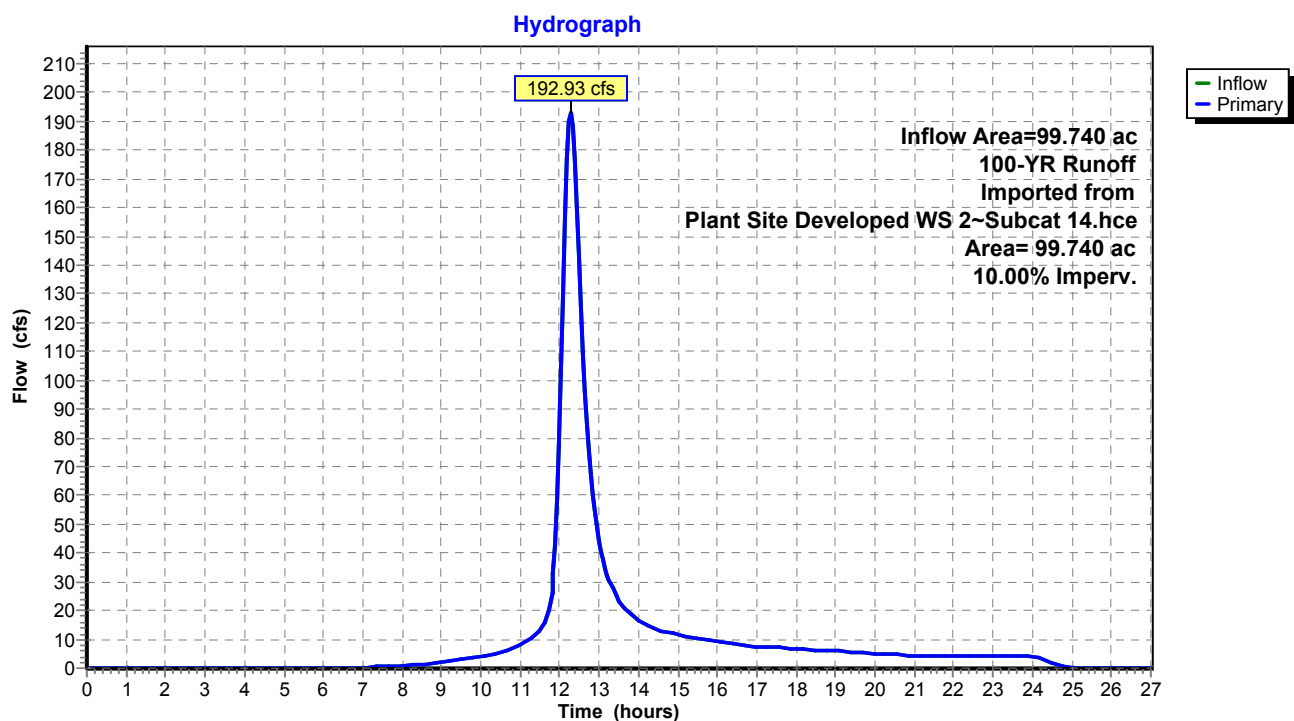
Inflow = 192.93 cfs @ 12.29 hrs, Volume= 20.338 af

Primary = 192.93 cfs @ 12.29 hrs, Volume= 20.338 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 14.hce

Link WS14: WS 14 Outflow



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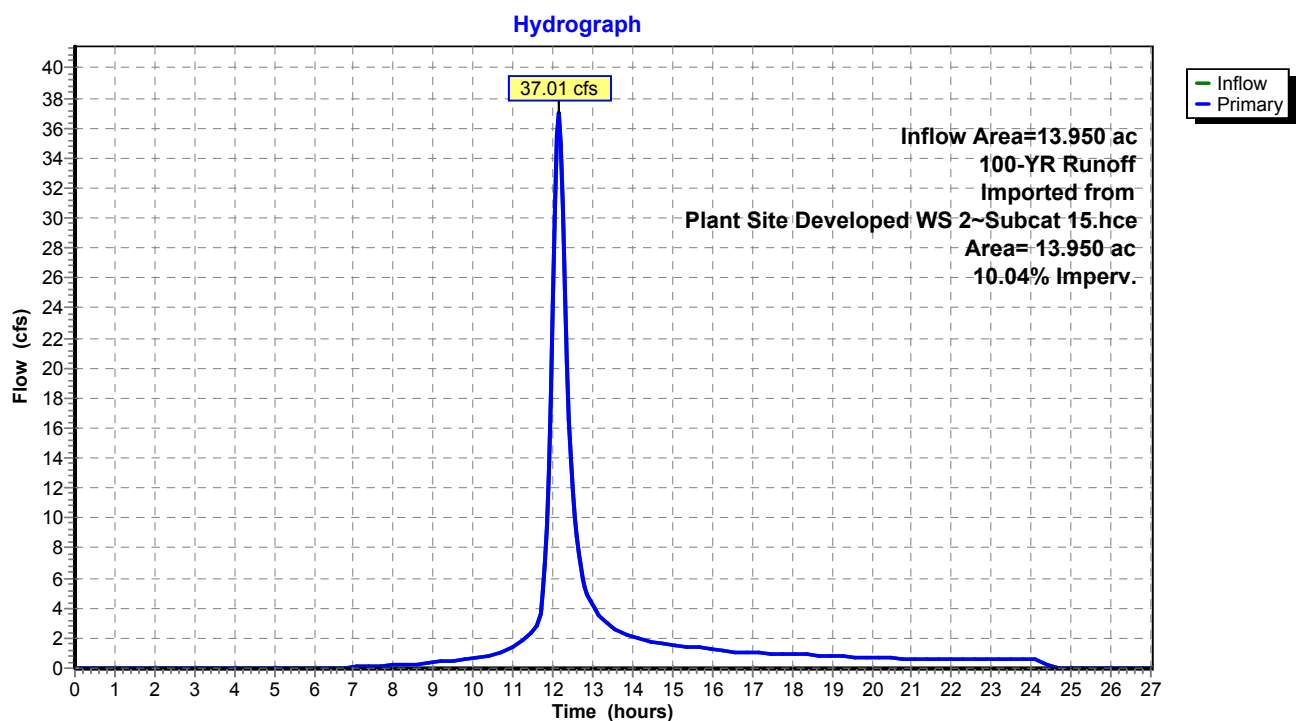
Summary for Link WS15: WS 15 Outflow

Inflow Area = 13.950 ac, 10.04% Impervious, Inflow Depth = 2.54" for 100-YR event
Inflow = 37.01 cfs @ 12.15 hrs, Volume= 2.948 af
Primary = 37.01 cfs @ 12.15 hrs, Volume= 2.948 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 15.hce

Link WS15: WS 15 Outflow



Plant Site Flow Routing 2

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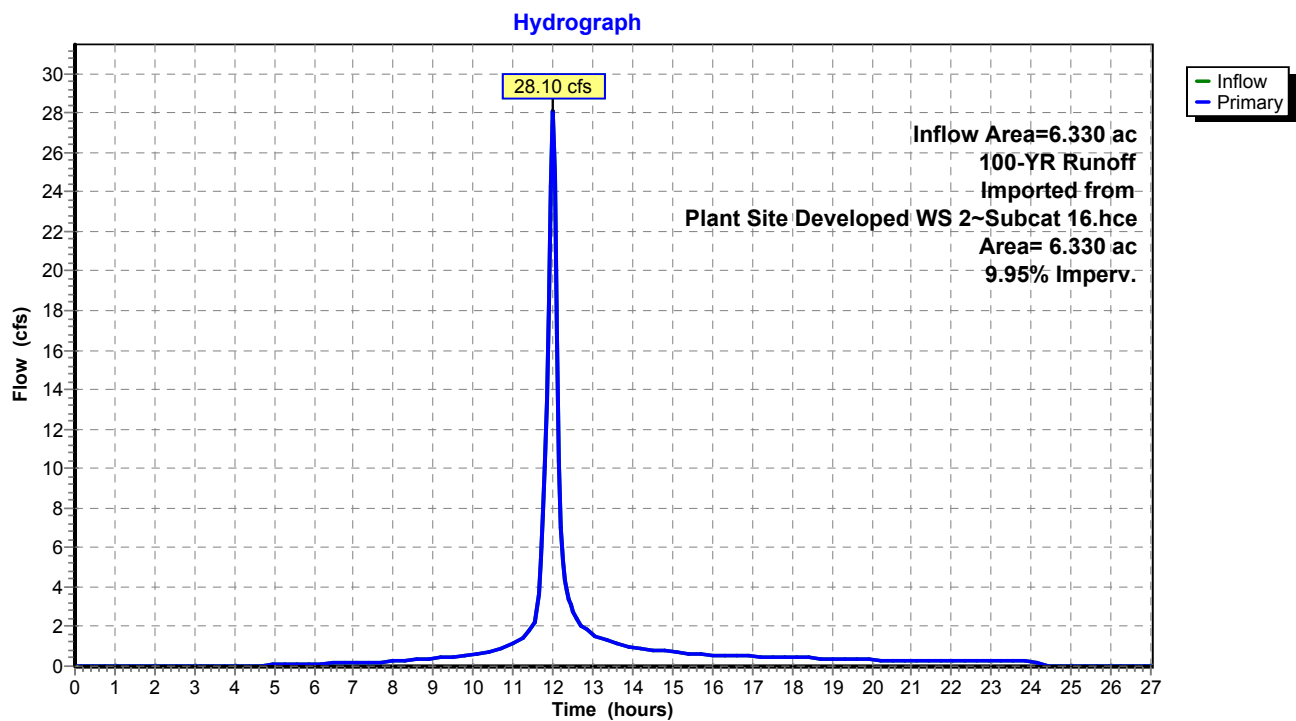
Summary for Link WS16: WS 16 Outflow

Inflow Area = 6.330 ac, 9.95% Impervious, Inflow Depth = 3.01" for 100-YR event
Inflow = 28.10 cfs @ 12.00 hrs, Volume= 1.589 af
Primary = 28.10 cfs @ 12.00 hrs, Volume= 1.589 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 16.hce

Link WS16: WS 16 Outflow



Plant Site Flow Routing 2

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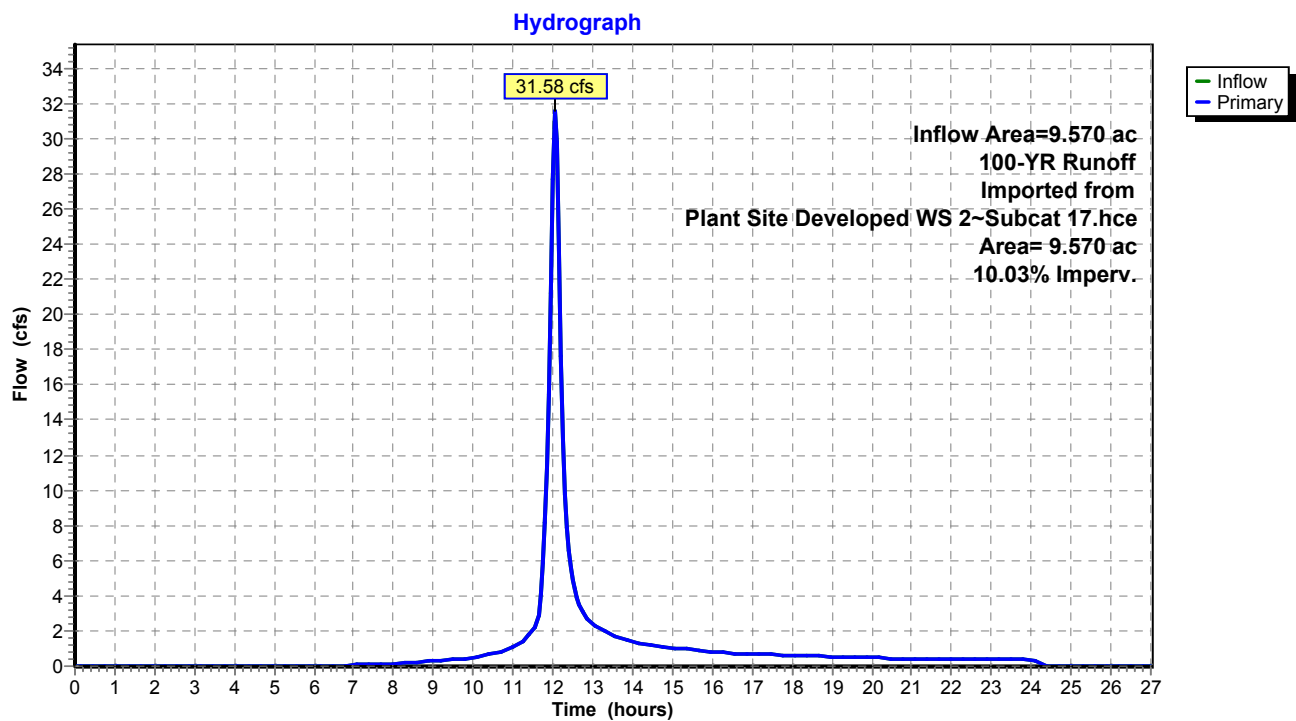
Summary for Link WS17: WS 17 Outflow

Inflow Area = 9.570 ac, 10.03% Impervious, Inflow Depth = 2.54" for 100-YR event
Inflow = 31.58 cfs @ 12.06 hrs, Volume= 2.022 af
Primary = 31.58 cfs @ 12.06 hrs, Volume= 2.022 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 17.hce

Link WS17: WS 17 Outflow



Plant Site Flow Routing 2

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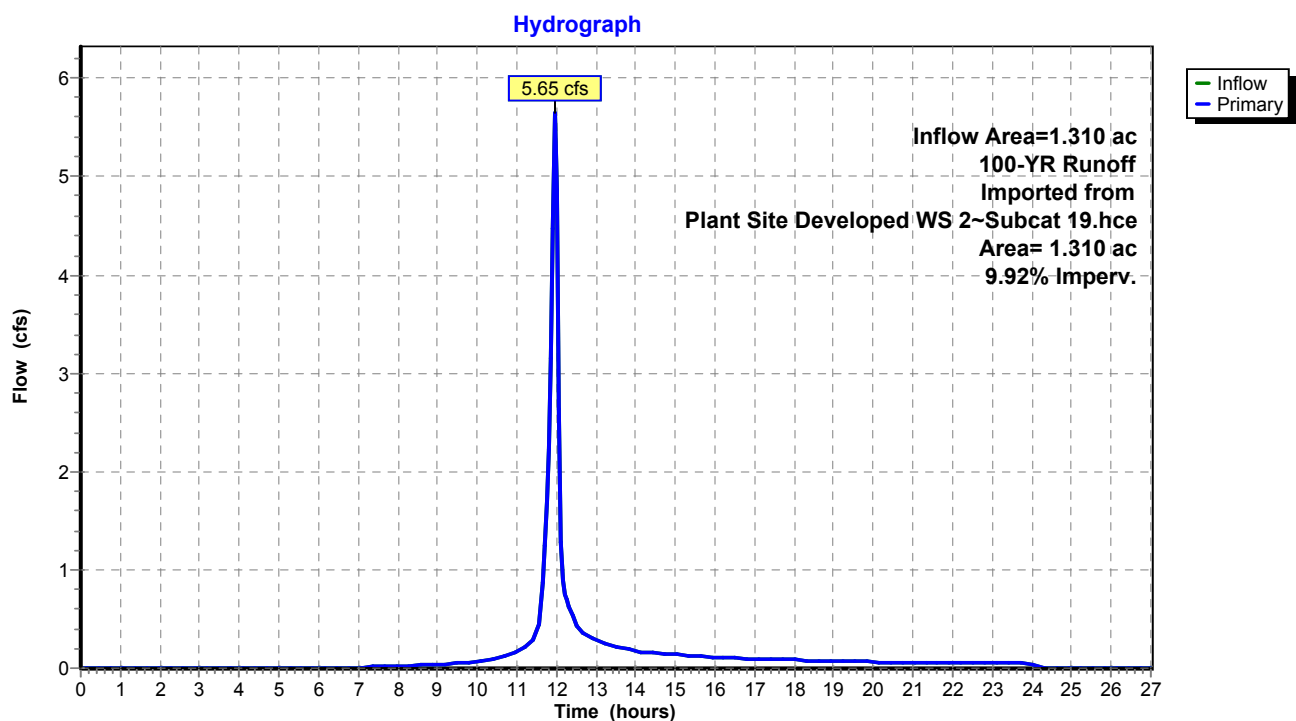
Summary for Link WS19: Watershed 19 Outflow

Inflow Area = 1.310 ac, 9.92% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 5.65 cfs @ 11.95 hrs, Volume= 0.267 af
Primary = 5.65 cfs @ 11.95 hrs, Volume= 0.267 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS 2~Subcat 19.hce

Link WS19: Watershed 19 Outflow



Plant Site Flow Routing 2

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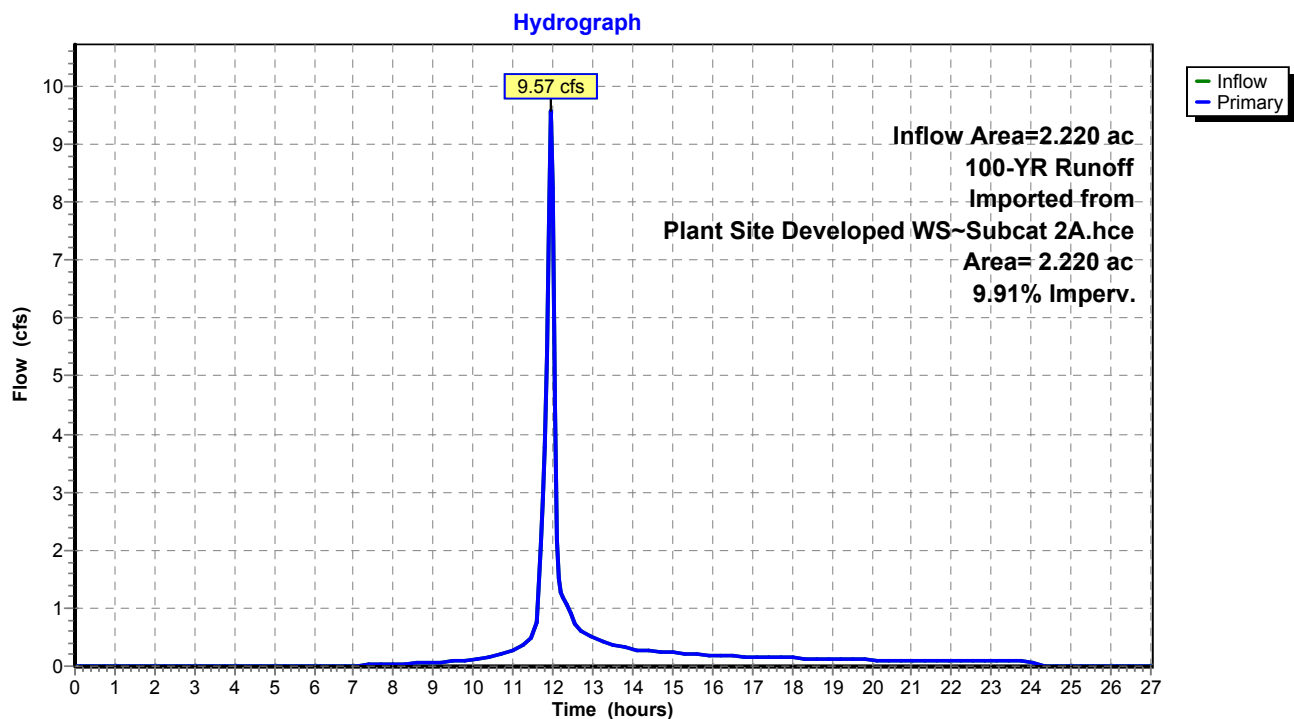
Summary for Link WS2A: Watershed 2A Outflow

Inflow Area = 2.220 ac, 9.91% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 9.57 cfs @ 11.95 hrs, Volume= 0.453 af
Primary = 9.57 cfs @ 11.95 hrs, Volume= 0.453 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 2A.hce

Link WS2A: Watershed 2A Outflow



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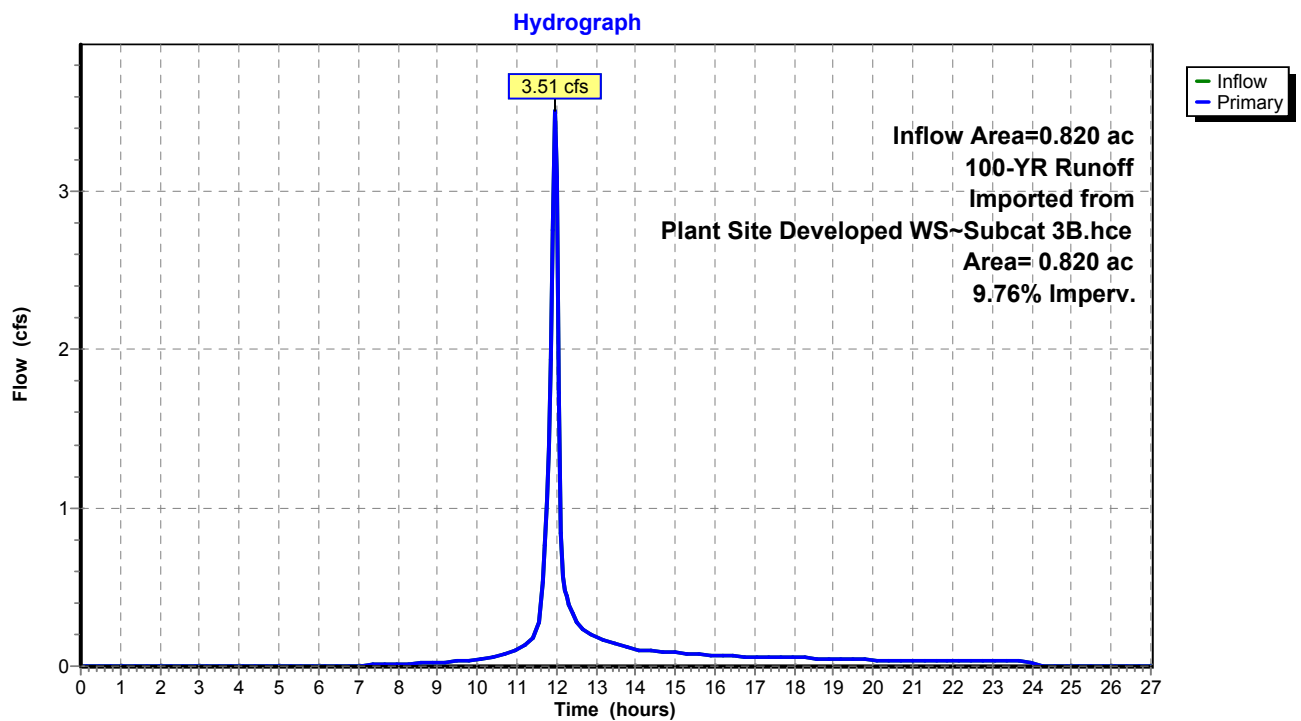
Summary for Link WS3B: Watershed 3B Outflow

Inflow Area = 0.820 ac, 9.76% Impervious, Inflow Depth = 2.45" for 100-YR event
Inflow = 3.51 cfs @ 11.96 hrs, Volume= 0.167 af
Primary = 3.51 cfs @ 11.96 hrs, Volume= 0.167 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-27.00 hrs, dt= 0.05 hrs

100-YR Runoff Imported from Plant Site Developed WS~Subcat 3B.hce

Link WS3B: Watershed 3B Outflow



APPENDIX D – FHWA HY-8 CULVERT ANALYSIS RESULTS



M3-PN160076
29 AUG 2016
Revision 2

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 55.18 cfs

Maximum Flow: 55.18 cfs

Table 1 - Summary of Culvert Flows at Crossing: Culvert 1

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
4800.00	0.00	0.00	0.00	1
4800.90	5.52	5.52	0.00	1
4801.29	11.04	11.04	0.00	1
4801.60	16.55	16.55	0.00	1
4801.87	22.07	22.07	0.00	1
4802.12	27.59	27.59	0.00	1
4802.36	33.11	33.11	0.00	1
4802.59	38.63	38.63	0.00	1
4802.81	44.14	44.14	0.00	1
4803.02	49.66	49.66	0.00	1
4803.24	55.18	55.18	0.00	1
4805.00	97.64	97.64	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
	0.00	0.00	4800.00	0.000	0.000	0-NF	0.000	0.000	1.780	1.780	0.000
	5.52	5.52	4800.90	0.899	0.0*	1-JS1t	0.521	0.677	1.780	1.780	1.021
	11.04	11.04	4801.29	1.289	0.0*	1-JS1t	0.766	0.965	1.780	1.780	2.041
	16.55	16.55	4801.60	1.600	0.0*	1-S2n	0.930	1.191	0.930	1.780	7.396
	22.07	22.07	4801.87	1.865	0.0*	1-S2n	1.093	1.382	1.093	1.780	7.927
	27.59	27.59	4802.12	2.116	0.0*	1-S2n	1.217	1.551	1.217	1.780	8.498
	33.11	33.11	4802.36	2.357	0.0*	1-S2n	1.341	1.707	1.341	1.780	8.930
	38.63	38.63	4802.59	2.587	0.0*	1-S2n	1.464	1.854	1.464	1.780	9.279
	44.14	44.14	4802.81	2.808	0.0*	1-S2n	1.569	1.987	1.569	1.780	9.645
	49.66	49.66	4803.02	3.024	0.0*	1-S2n	1.674	2.111	1.679	1.780	9.908
	55.18	55.18	4803.24	3.237	0.0*	1-S2n	1.779	2.230	1.779	1.780	10.215

* Full Flow Headwater elevation is below inlet invert.

Straight Culvert
Inlet Elevation (invert): 4800.00 ft, Outlet Elevation (invert): 4794.00 ft
Culvert Length: 200.09 ft, Culvert Slope: 0.0300

Site Data - Culvert 1

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 4800.00 ft
Outlet Station: 200.00 ft
Outlet Elevation: 4794.00 ft
Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular
Barrel Diameter: 4.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Square Edge with Headwall
Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Culvert 1)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	4795.78	1.78
5.52	4795.78	1.78
11.04	4795.78	1.78
16.55	4795.78	1.78
22.07	4795.78	1.78
27.59	4795.78	1.78
33.11	4795.78	1.78
38.63	4795.78	1.78
44.14	4795.78	1.78
49.66	4795.78	1.78
55.18	4795.78	1.78

Tailwater Channel Data - Culvert 1

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 4795.78 ft

Roadway Data for Crossing: Culvert 1

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 5.00 ft

Crest Elevation: 4805.00 ft

Roadway Surface: Gravel

Roadway Top Width: 75.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 64.68 cfs

Maximum Flow: 64.68 cfs

Table 4 - Summary of Culvert Flows at Crossing: Culvert 2

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 2 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
4770.00	0.00	0.00	0.00	1
4770.99	6.47	6.47	0.00	1
4771.41	12.94	12.94	0.00	1
4771.75	19.40	19.40	0.00	1
4772.05	25.87	25.87	0.00	1
4772.33	32.34	32.34	0.00	1
4772.60	38.81	38.81	0.00	1
4772.86	45.28	45.28	0.00	1
4773.11	51.74	51.74	0.00	1
4773.36	58.21	58.21	0.00	1
4773.61	64.68	64.68	0.00	1
4775.00	97.46	97.46	0.00	Overtopping

Table 5 - Culvert Summary Table: Culvert 2

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
	0.00	0.00	4770.00	0.000	0.000	0-NF	0.000	0.000	2.050	2.050	0.000
	6.47	6.47	4770.99	0.986	0.0*	1-JS1t	0.591	0.735	2.050	2.050	0.998
	12.94	12.94	4771.41	1.410	0.0*	1-JS1t	0.852	1.048	2.050	2.050	1.995
	19.40	19.40	4771.75	1.747	0.0*	1-JS1t	1.059	1.291	2.050	2.050	2.993
	25.87	25.87	4772.05	2.046	0.0*	1-S2n	1.224	1.499	1.224	2.050	7.913
	32.34	32.34	4772.33	2.333	0.0*	1-S2n	1.380	1.686	1.380	2.050	8.397
	38.81	38.81	4772.60	2.603	0.0*	1-S2n	1.524	1.858	1.524	2.050	8.817
	45.28	45.28	4772.86	2.861	0.0*	1-S2n	1.657	2.014	1.657	2.050	9.198
	51.74	51.74	4773.11	3.113	0.060	1-S2n	1.789	2.155	1.789	2.050	9.506
	58.21	58.21	4773.36	3.361	0.438	1-S2n	1.913	2.292	1.913	2.050	9.804
	64.68	64.68	4773.61	3.611	0.838	1-S2n	2.035	2.424	2.046	2.050	9.999

* Full Flow Headwater elevation is below inlet invert.

Straight Culvert
Inlet Elevation (invert): 4770.00 ft, Outlet Elevation (invert): 4767.00 ft
Culvert Length: 116.04 ft, Culvert Slope: 0.0259

Site Data - Culvert 2

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 4770.00 ft
Outlet Station: 116.00 ft
Outlet Elevation: 4767.00 ft
Number of Barrels: 1

Culvert Data Summary - Culvert 2

Barrel Shape: Circular
Barrel Diameter: 4.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Square Edge with Headwall
Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: Culvert 2)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	4769.05	2.05
6.47	4769.05	2.05
12.94	4769.05	2.05
19.40	4769.05	2.05
25.87	4769.05	2.05
32.34	4769.05	2.05
38.81	4769.05	2.05
45.28	4769.05	2.05
51.74	4769.05	2.05
58.21	4769.05	2.05
64.68	4769.05	2.05

Tailwater Channel Data - Culvert 2

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 4769.05 ft

Roadway Data for Crossing: Culvert 2

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 5.00 ft

Crest Elevation: 4775.00 ft

Roadway Surface: Gravel

Roadway Top Width: 50.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 17.25 cfs

Maximum Flow: 17.25 cfs

Table 7 - Summary of Culvert Flows at Crossing: Culvert 3

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 3 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
4770.00	0.00	0.00	0.00	1
4770.65	1.73	1.73	0.00	1
4770.82	3.45	3.45	0.00	1
4771.16	5.18	5.18	0.00	1
4771.35	6.90	6.90	0.00	1
4771.52	8.63	8.63	0.00	1
4771.68	10.35	10.35	0.00	1
4771.83	12.08	12.08	0.00	1
4771.97	13.80	13.80	0.00	1
4772.10	15.53	15.53	0.00	1
4772.24	17.25	17.25	0.00	1
4777.00	37.76	37.76	0.00	Overtopping

Table 8 - Culvert Summary Table: Culvert 3

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
	0.00	0.00	4770.00	0.000	0.000	0-NF	0.000	0.000	1.400	1.400	0.000
	1.73	1.73	4770.65	0.574	0.649	3-M1t	0.431	0.422	1.400	1.400	0.610
	3.45	3.45	4770.82	0.823	0.0*	1-S2n	0.607	0.607	0.607	1.400	3.720
	5.18	5.18	4771.16	1.022	1.159	3-M1t	0.751	0.747	1.400	1.400	1.830
	6.90	6.90	4771.35	1.192	1.348	3-M1t	0.877	0.866	1.400	1.400	2.439
	8.63	8.63	4771.52	1.353	1.521	3-M1t	0.988	0.976	1.400	1.400	3.049
	10.35	10.35	4771.68	1.505	1.679	3-M1t	1.095	1.074	1.400	1.400	3.659
	12.08	12.08	4771.83	1.649	1.828	3-M1t	1.196	1.166	1.400	1.400	4.269
	13.80	13.80	4771.97	1.789	1.969	3-M1t	1.294	1.250	1.400	1.400	4.879
	15.53	15.53	4772.10	1.925	2.104	3-M1t	1.392	1.327	1.400	1.400	5.489
	17.25	17.25	4772.24	2.060	2.236	2-M2c	1.489	1.403	1.403	1.400	6.084

* Full Flow Headwater elevation is below inlet invert.

Straight Culvert
Inlet Elevation (invert): 4770.00 ft, Outlet Elevation (invert): 4767.00 ft
Culvert Length: 220.02 ft, Culvert Slope: 0.0136

Site Data - Culvert 3

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 4770.00 ft
Outlet Station: 220.00 ft
Outlet Elevation: 4767.00 ft
Number of Barrels: 1

Culvert Data Summary - Culvert 3

Barrel Shape: Circular
Barrel Diameter: 2.50 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Square Edge with Headwall
Inlet Depression: NONE

Table 9 - Downstream Channel Rating Curve (Crossing: Culvert 3)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	4768.40	1.40
1.73	4768.40	1.40
3.45	4768.40	1.40
5.18	4768.40	1.40
6.90	4768.40	1.40
8.63	4768.40	1.40
10.35	4768.40	1.40
12.08	4768.40	1.40
13.80	4768.40	1.40
15.53	4768.40	1.40
17.25	4768.40	1.40

Tailwater Channel Data - Culvert 3

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 4768.40 ft

Roadway Data for Crossing: Culvert 3

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 5.00 ft

Crest Elevation: 4777.00 ft

Roadway Surface: Gravel

Roadway Top Width: 50.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 137.01 cfs

Maximum Flow: 137.01 cfs

Table 10 - Summary of Culvert Flows at Crossing: Culvert 4

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 4 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
4767.90	0.00	0.00	0.00	1
4768.91	13.70	13.70	0.00	1
4769.35	27.40	27.40	0.00	1
4769.69	41.10	41.10	0.00	1
4770.00	54.80	54.80	0.00	1
4770.30	68.50	68.50	0.00	1
4770.58	82.21	82.21	0.00	1
4770.85	95.91	95.91	0.00	1
4771.12	109.61	109.61	0.00	1
4771.38	123.31	123.31	0.00	1
4771.65	137.01	137.01	0.00	1
4783.10	426.12	426.12	0.00	Overtopping

Table 11 - Culvert Summary Table: Culvert 4

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
	0.00	0.00	4767.90	0.000	0.000	0-NF	0.000	0.000	1.980	1.980	0.000
	13.70	13.70	4768.91	1.013	0.0*	1-JS1t	0.577	0.757	1.980	1.980	1.104
	27.40	27.40	4769.35	1.447	0.0*	1-JS1t	0.835	1.080	1.980	1.980	2.209
	41.10	41.10	4769.69	1.792	0.0*	1-S2n	1.033	1.331	1.033	1.980	7.953
	54.80	54.80	4770.00	2.104	0.0*	1-S2n	1.198	1.545	1.198	1.980	8.636
	68.50	68.50	4770.30	2.403	0.0*	1-S2n	1.348	1.739	1.348	1.980	9.181
	82.21	82.21	4770.58	2.684	0.0*	1-S2n	1.491	1.915	1.491	1.980	9.639
	95.91	95.91	4770.85	2.954	0.0*	1-S2n	1.618	2.074	1.618	1.980	10.051
	109.61	109.61	4771.12	3.219	0.0*	1-S2n	1.745	2.223	1.745	1.980	10.399
	123.31	123.31	4771.38	3.482	0.0*	1-S2n	1.868	2.365	1.868	1.980	10.719
	137.01	137.01	4771.65	3.749	0.0*	1-S2n	1.985	2.497	1.985	1.980	11.010

* Full Flow Headwater elevation is below inlet invert.

Straight Culvert
Inlet Elevation (invert): 4767.90 ft, Outlet Elevation (invert): 4763.10 ft
Culvert Length: 152.08 ft, Culvert Slope: 0.0316

Site Data - Culvert 4

Site Data Option: Culvert Invert Data
Inlet Station: 0.00 ft
Inlet Elevation: 4767.90 ft
Outlet Station: 152.00 ft
Outlet Elevation: 4763.10 ft
Number of Barrels: 2

Culvert Data Summary - Culvert 4

Barrel Shape: Circular
Barrel Diameter: 4.00 ft
Barrel Material: Corrugated Steel
Embedment: 0.00 in
Barrel Manning's n: 0.0240
Culvert Type: Straight
Inlet Configuration: Square Edge with Headwall
Inlet Depression: NONE

Table 12 - Downstream Channel Rating Curve (Crossing: Culvert 4)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	4765.08	1.98
13.70	4765.08	1.98
27.40	4765.08	1.98
41.10	4765.08	1.98
54.80	4765.08	1.98
68.50	4765.08	1.98
82.21	4765.08	1.98
95.91	4765.08	1.98
109.61	4765.08	1.98
123.31	4765.08	1.98
137.01	4765.08	1.98

Tailwater Channel Data - Culvert 4

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 4765.08 ft

Roadway Data for Crossing: Culvert 4

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 5.00 ft

Crest Elevation: 4783.10 ft

Roadway Surface: Gravel

Roadway Top Width: 50.00 ft

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 12.19 cfs

Maximum Flow: 12.19 cfs

Table 13 - Summary of Culvert Flows at Crossing: Culvert 5

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 5 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
4760.65	0.00	0.00	0.00	1
4761.12	1.22	1.22	0.00	1
4761.33	2.44	2.44	0.00	1
4761.50	3.66	3.66	0.00	1
4761.64	4.88	4.88	0.00	1
4761.76	6.09	6.09	0.00	1
4761.87	7.31	7.31	0.00	1
4761.99	8.53	8.53	0.00	1
4762.10	9.75	9.75	0.00	1
4762.20	10.97	10.97	0.00	1
4762.30	12.19	12.19	0.00	1
4765.00	34.32	34.32	0.00	Overtopping

Table 14 - Culvert Summary Table: Culvert 5

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
	0.00	0.00	4760.65	0.000	0.000	0-NF	0.000	0.000	1.090	1.090	0.000
	1.22	1.22	4761.12	0.473	0.0*	1-JS1t	0.321	0.356	1.090	1.090	0.593
	2.44	2.44	4761.33	0.684	0.0*	1-S2n	0.473	0.506	0.473	1.090	3.801
	3.66	3.66	4761.50	0.846	0.0*	1-JS1t	0.573	0.625	1.090	1.090	1.778
	4.88	4.88	4761.64	0.990	0.0*	1-JS1t	0.673	0.724	1.090	1.090	2.371
	6.09	6.09	4761.76	1.109	0.0*	1-JS1t	0.751	0.814	1.090	1.090	2.963
	7.31	7.31	4761.87	1.224	0.0*	1-S2n	0.826	0.893	0.826	1.090	5.151
	8.53	8.53	4761.99	1.338	0.0*	1-S2n	0.902	0.970	0.902	1.090	5.349
	9.75	9.75	4762.10	1.446	0.0*	1-S2n	0.967	1.040	0.967	1.090	5.560
	10.97	10.97	4762.20	1.551	0.0*	1-S2n	1.030	1.108	1.030	1.090	5.742
	12.19	12.19	4762.30	1.652	0.0*	1-S2n	1.094	1.172	1.094	1.090	5.896

* Full Flow Headwater elevation is below inlet invert.

Straight Culvert
Inlet Elevation (invert): 4760.65 ft, Outlet Elevation (invert): 4756.00 ft
Culvert Length: 245.54 ft, Culvert Slope: 0.0189

Site Data - Culvert 5

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 4760.65 ft

Outlet Station: 245.50 ft

Outlet Elevation: 4756.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 5

Barrel Shape: Circular

Barrel Diameter: 2.50 ft

Barrel Material: Corrugated Steel

Embedment: 0.00 in

Barrel Manning's n: 0.0240

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

Table 15 - Downstream Channel Rating Curve (Crossing: Culvert 5)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	4757.09	1.09
1.22	4757.09	1.09
2.44	4757.09	1.09
3.66	4757.09	1.09
4.88	4757.09	1.09
6.09	4757.09	1.09
7.31	4757.09	1.09
8.53	4757.09	1.09
9.75	4757.09	1.09
10.97	4757.09	1.09
12.19	4757.09	1.09

Tailwater Channel Data - Culvert 5

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 4757.09 ft

Roadway Data for Crossing: Culvert 5

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 5.00 ft

Crest Elevation: 4765.00 ft

Roadway Surface: Gravel

Roadway Top Width: 240.00 ft

APPENDIX E – FHWA HYDRAULIC TOOLBOX CHANNEL ANALYSIS RESULTS



M3-PN160076
29 AUG 2016
Revision 2

Hydraulic Analysis Report

Project Data

Project Title: Gunnison Copper Plant Site Channels

Designer: A Edwards

Project Date: Monday, August 29, 2016

Project Units: U.S. Customary Units

Notes: Rev 2

Channel Analysis: WS 2B Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0538 ft/ft

Manning's n: 0.0350

Flow: 11.4400 cfs

Result Parameters

Depth: 0.9975 ft

Area of Flow: 1.9898 ft²

Wetted Perimeter: 4.4607 ft

Average Velocity: 5.7493 ft/s

Top Width: 3.9898 ft

Froude Number: 1.4347

Critical Depth: 1.1524 ft

Critical Velocity: 4.3073 ft/s

Critical Slope: 0.0249 ft/ft

Critical Top Width: 4.6095 ft

Calculated Max Shear Stress: 3.3486 lb/ft²

Calculated Avg Shear Stress: 1.4975 lb/ft²

Channel Analysis: WS 3A Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0250 ft/ft

Manning's n: 0.0250

Flow: 6.9900 cfs

Result Parameters

Depth: 0.8439 ft

Area of Flow: 1.4242 ft²

Wetted Perimeter: 3.7739 ft

Average Velocity: 4.9080 ft/s

Top Width: 3.3754 ft

Froude Number: 1.3316

Critical Depth: 0.9463 ft

Critical Velocity: 3.9032 ft/s

Critical Slope: 0.0136 ft/ft

Critical Top Width: 3.7851 ft

Calculated Max Shear Stress: 1.3164 lb/ft²

Calculated Avg Shear Stress: 0.5887 lb/ft²

Channel Analysis: WS 3C Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0100 ft/ft

Manning's n: 0.0250

Flow: 4.9600 cfs

Result Parameters

Depth: 0.8811 ft

Area of Flow: 1.5526 ft²

Wetted Perimeter: 3.9403 ft

Average Velocity: 3.1947 ft/s

Top Width: 3.5243 ft

Froude Number: 0.8482

Critical Depth: 0.8249 ft

Critical Velocity: 3.6444 ft/s

Critical Slope: 0.0142 ft/ft

Critical Top Width: 3.2997 ft

Calculated Max Shear Stress: 0.5498 lb/ft²

Calculated Avg Shear Stress: 0.2459 lb/ft²

Channel Analysis: WS 4 Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0150 ft/ft

Manning's n: 0.0350

Flow: 17.8500 cfs

Result Parameters

Depth: 1.4974 ft

Area of Flow: 4.4847 ft²

Wetted Perimeter: 6.6968 ft

Average Velocity: 3.9802 ft/s

Top Width: 5.9898 ft

Froude Number: 0.8106

Critical Depth: 1.3768 ft

Critical Velocity: 4.7082 ft/s

Critical Slope: 0.0235 ft/ft

Critical Top Width: 5.5073 ft

Calculated Max Shear Stress: 1.4016 lb/ft²

Calculated Avg Shear Stress: 0.6268 lb/ft²

Channel Analysis: WS 6 Channel (Beginning)

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0237 ft/ft

Manning's n: 0.0350

Flow: 55.1800 cfs

Result Parameters

Depth: 1.3502 ft

Area of Flow: 9.0466 ft²

Wetted Perimeter: 10.0381 ft

Average Velocity: 6.0995 ft/s

Top Width: 9.4007 ft

Froude Number: 1.0957

Critical Depth: 1.4197 ft

Critical Velocity: 5.6829 ft/s

Critical Slope: 0.0195 ft/ft

Critical Top Width: 9.6788 ft

Calculated Max Shear Stress: 1.9967 lb/ft²

Calculated Avg Shear Stress: 1.3328 lb/ft²

Channel Analysis: WS 6 Channel (End)

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0237 ft/ft

Manning's n: 0.0350

Flow: 69.0800 cfs

Result Parameters

Depth: 1.5153 ft

Area of Flow: 10.6531 ft²

Wetted Perimeter: 10.7765 ft

Average Velocity: 6.4845 ft/s

Top Width: 10.0611 ft

Froude Number: 1.1105

Critical Depth: 1.6036 ft

Critical Velocity: 5.9771 ft/s

Critical Slope: 0.0189 ft/ft

Critical Top Width: 10.4144 ft

Calculated Max Shear Stress: 2.2409 lb/ft²

Calculated Avg Shear Stress: 1.4620 lb/ft²

Channel Analysis: WS 7 Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0331 ft/ft

Manning's n: 0.0350

Flow: 11.9800 cfs

Result Parameters

Depth: 1.1116 ft

Area of Flow: 2.4714 ft²

Wetted Perimeter: 4.9713 ft

Average Velocity: 4.8474 ft/s

Top Width: 4.4465 ft

Froude Number: 1.1458

Critical Depth: 1.1738 ft

Critical Velocity: 4.3473 ft/s

Critical Slope: 0.0248 ft/ft

Critical Top Width: 4.6953 ft

Calculated Max Shear Stress: 2.2960 lb/ft²

Calculated Avg Shear Stress: 1.0268 lb/ft²

Channel Analysis: WS 8A Channel

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 5.0000 ft

Longitudinal Slope: 0.0238 ft/ft

Manning's n: 0.0350

Flow: 118.2400 cfs

Result Parameters

Depth: 1.8371 ft

Area of Flow: 15.9359 ft²

Wetted Perimeter: 13.2160 ft

Average Velocity: 7.4197 ft/s

Top Width: 12.3486 ft

Froude Number: 1.1510

Critical Depth: 1.9829 ft

Critical Velocity: 6.6510 ft/s

Critical Slope: 0.0176 ft/ft

Critical Top Width: 12.9314 ft

Calculated Max Shear Stress: 2.7284 lb/ft²

Calculated Avg Shear Stress: 1.7908 lb/ft²

Channel Analysis: WS 8B Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0100 ft/ft

Manning's n: 0.0250

Flow: 12.1700 cfs

Result Parameters

Depth: 1.2336 ft

Area of Flow: 3.0437 ft²

Wetted Perimeter: 5.5170 ft

Average Velocity: 3.9984 ft/s

Top Width: 4.9346 ft

Froude Number: 0.8972

Critical Depth: 1.1812 ft

Critical Velocity: 4.3610 ft/s

Critical Slope: 0.0126 ft/ft

Critical Top Width: 4.7250 ft

Calculated Max Shear Stress: 0.7698 lb/ft²

Calculated Avg Shear Stress: 0.3443 lb/ft²

Channel Analysis: WS 9 Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0610 ft/ft

Manning's n: 0.0350

Flow: 26.3600 cfs

Result Parameters

Depth: 1.3323 ft

Area of Flow: 3.5502 ft²

Wetted Perimeter: 5.9583 ft

Average Velocity: 7.4250 ft/s

Top Width: 5.3293 ft

Froude Number: 1.6032

Critical Depth: 1.6092 ft

Critical Velocity: 5.0899 ft/s

Critical Slope: 0.0223 ft/ft

Critical Top Width: 6.4367 ft

Calculated Max Shear Stress: 5.0713 lb/ft²

Calculated Avg Shear Stress: 2.2680 lb/ft²

Channel Analysis: WS 10 Channel

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 5.0000 ft

Longitudinal Slope: 0.0167 ft/ft

Manning's n: 0.0350

Flow: 135.5400 cfs

Result Parameters

Depth: 2.1526 ft

Area of Flow: 20.0302 ft²

Wetted Perimeter: 14.6267 ft

Average Velocity: 6.7668 ft/s

Top Width: 13.6104 ft

Froude Number: 0.9830

Critical Depth: 2.1336 ft

Critical Velocity: 6.8548 ft/s

Critical Slope: 0.0173 ft/ft

Critical Top Width: 13.5345 ft

Calculated Max Shear Stress: 2.2432 lb/ft²

Calculated Avg Shear Stress: 1.4271 lb/ft²

Channel Analysis: WS 11 Swale (Beginning)

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0289 ft/ft

Manning's n: 0.0350

Flow: 6.3300 cfs

Result Parameters

Depth: 0.8977 ft

Area of Flow: 1.6116 ft²

Wetted Perimeter: 4.0145 ft

Average Velocity: 3.9278 ft/s

Top Width: 3.5906 ft

Froude Number: 1.0332

Critical Depth: 0.9095 ft

Critical Velocity: 3.8265 ft/s

Critical Slope: 0.0270 ft/ft

Critical Top Width: 3.6378 ft

Calculated Max Shear Stress: 1.6188 lb/ft²

Calculated Avg Shear Stress: 0.7240 lb/ft²

Channel Analysis: WS 11 Swale (End)

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0289 ft/ft

Manning's n: 0.0350

Flow: 18.2300 cfs

Result Parameters

Depth: 1.3347 ft

Area of Flow: 3.5628 ft²

Wetted Perimeter: 5.9689 ft

Average Velocity: 5.1168 ft/s

Top Width: 5.3388 ft

Froude Number: 1.1038

Critical Depth: 1.3885 ft

Critical Velocity: 4.7280 ft/s

Critical Slope: 0.0234 ft/ft

Critical Top Width: 5.5539 ft

Calculated Max Shear Stress: 2.4069 lb/ft²

Calculated Avg Shear Stress: 1.0764 lb/ft²

Channel Analysis: WS 12&13 Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0800 ft/ft

Manning's n: 0.0350

Flow: 2.1300 cfs

Result Parameters

Depth: 0.4930 ft

Area of Flow: 0.4860 ft²

Wetted Perimeter: 2.2046 ft

Average Velocity: 4.3824 ft/s

Top Width: 1.9719 ft

Froude Number: 1.5556

Critical Depth: 0.5883 ft

Critical Velocity: 3.0775 ft/s

Critical Slope: 0.0312 ft/ft

Critical Top Width: 2.3531 ft

Calculated Max Shear Stress: 2.4609 lb/ft²

Calculated Avg Shear Stress: 1.1005 lb/ft²

Channel Analysis: WS 15 Diversion Channel - BGN

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 3.0000 ft

Longitudinal Slope: 0.0208 ft/ft

Manning's n: 0.0350

Flow: 37.0100 cfs

Result Parameters

Depth: 1.2622 ft

Area of Flow: 6.9732 ft²

Wetted Perimeter: 8.6449 ft

Average Velocity: 5.3075 ft/s

Top Width: 8.0489 ft

Froude Number: 1.0049

Critical Depth: 1.2659 ft

Critical Velocity: 5.2853 ft/s

Critical Slope: 0.0206 ft/ft

Critical Top Width: 8.0635 ft

Calculated Max Shear Stress: 1.6383 lb/ft²

Calculated Avg Shear Stress: 1.0469 lb/ft²

Channel Analysis: WS 15 Diversion Channel - END

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 3.0000 ft

Longitudinal Slope: 0.0208 ft/ft

Manning's n: 0.0350

Flow: 55.5100 cfs

Result Parameters

Depth: 1.5427 ft

Area of Flow: 9.3876 ft²

Wetted Perimeter: 9.8990 ft

Average Velocity: 5.9131 ft/s

Top Width: 9.1707 ft

Froude Number: 1.0299

Critical Depth: 1.5670 ft

Critical Velocity: 5.7749 ft/s

Critical Slope: 0.0195 ft/ft

Critical Top Width: 9.2681 ft

Calculated Max Shear Stress: 2.0023 lb/ft²

Calculated Avg Shear Stress: 1.2309 lb/ft²

Channel Analysis: WS 17 Diversion Channel - BGN

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 5.0000 ft

Longitudinal Slope: 0.0141 ft/ft

Manning's n: 0.0350

Flow: 158.3600 cfs

Result Parameters

Depth: 2.4253 ft

Area of Flow: 23.8911 ft²

Wetted Perimeter: 15.8464 ft

Average Velocity: 6.6284 ft/s

Top Width: 14.7013 ft

Froude Number: 0.9163

Critical Depth: 2.3173 ft

Critical Velocity: 7.0930 ft/s

Critical Slope: 0.0170 ft/ft

Critical Top Width: 14.2692 ft

Calculated Max Shear Stress: 2.1339 lb/ft²

Calculated Avg Shear Stress: 1.3265 lb/ft²

Channel Analysis: WS 17 Diversion Channel - END

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 5.0000 ft

Longitudinal Slope: 0.0141 ft/ft

Manning's n: 0.0350

Flow: 165.5700 cfs

Result Parameters

Depth: 2.4791 ft

Area of Flow: 24.6866 ft²

Wetted Perimeter: 16.0867 ft

Average Velocity: 6.7069 ft/s

Top Width: 14.9162 ft

Froude Number: 0.9187

Critical Depth: 2.3722 ft

Critical Velocity: 7.1625 ft/s

Critical Slope: 0.0169 ft/ft

Critical Top Width: 14.4889 ft

Calculated Max Shear Stress: 2.1812 lb/ft²

Calculated Avg Shear Stress: 1.3502 lb/ft²

Channel Analysis: WS 19 Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0100 ft/ft

Manning's n: 0.0250

Flow: 5.6500 cfs

Result Parameters

Depth: 0.9252 ft

Area of Flow: 1.7119 ft²

Wetted Perimeter: 4.1375 ft

Average Velocity: 3.3004 ft/s

Top Width: 3.7007 ft

Froude Number: 0.8552

Critical Depth: 0.8690 ft

Critical Velocity: 3.7405 ft/s

Critical Slope: 0.0140 ft/ft

Critical Top Width: 3.4762 ft

Calculated Max Shear Stress: 0.5773 lb/ft²

Calculated Avg Shear Stress: 0.2582 lb/ft²

Channel Analysis: WS 20 Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0339 ft/ft

Manning's n: 0.0250

Flow: 4.5000 cfs

Result Parameters

Depth: 0.6757 ft

Area of Flow: 0.9131 ft²

Wetted Perimeter: 3.0218 ft

Average Velocity: 4.9282 ft/s

Top Width: 2.7028 ft

Froude Number: 1.4942

Critical Depth: 0.7934 ft

Critical Velocity: 3.5741 ft/s

Critical Slope: 0.0144 ft/ft

Critical Top Width: 3.1737 ft

Calculated Max Shear Stress: 1.4293 lb/ft²

Calculated Avg Shear Stress: 0.6392 lb/ft²

Channel Analysis: WS 21 Swale

Notes:

Input Parameters

Channel Type: Triangular

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Longitudinal Slope: 0.0176 ft/ft

Manning's n: 0.0250

Flow: 7.7800 cfs

Result Parameters

Depth: 0.9382 ft

Area of Flow: 1.7604 ft²

Wetted Perimeter: 4.1957 ft

Average Velocity: 4.4195 ft/s

Top Width: 3.7527 ft

Froude Number: 1.1371

Critical Depth: 0.9877 ft

Critical Velocity: 3.9877 ft/s

Critical Slope: 0.0134 ft/ft

Critical Top Width: 3.9507 ft

Calculated Max Shear Stress: 1.0304 lb/ft²

Calculated Avg Shear Stress: 0.4608 lb/ft²

Channel Analysis: WS 6 Channel Lining Calc

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 4.0000 ft

Longitudinal Slope: 0.0237 ft/ft

Manning's n: 0.0706

Flow: 67.2800 cfs

Result Parameters

Depth: 2.1202 ft

Area of Flow: 17.4715 ft²

Wetted Perimeter: 13.4819 ft

Average Velocity: 3.8508 ft/s

Top Width: 12.4809 ft

Froude Number: 0.5736

Critical Depth: 1.5811 ft

Critical Velocity: 5.9415 ft/s

Critical Slope: 0.0774 ft/ft

Critical Top Width: 10.3242 ft

Calculated Max Shear Stress: 3.1355 lb/ft²

Calculated Avg Shear Stress: 1.9165 lb/ft²

Channel Lining Analysis: WS 6 Lining

Notes:

Lining Input Parameters

Channel Lining Type: Riprap, Cobble, or Gravel

D50: 0.67 ft

Riprap Specific Weight: 165 lb/ft³

Water Specific Weight: 62.4 lb/ft³

Riprap Shape is Angular

Safety Factor: 1

Calculated Safety Factor: 1.094

Lining Results

Angle of Repose: 41.5 degrees

Relative Flow Depth: 2.08935

Manning's n method: Blodgett

Manning's n: 0.0706249

Channel Bottom Shear Results

V*: 1.27201

Reynold's Number: 70028.7

Shield's Parameter: 0.066331

shear stress on channel bottom: 3.13554 lb/ft²

Permissible shear stress for channel bottom: 4.55973 lb/ft²

channel bottom is stable

Stable D50: 0.504039 ft

Channel Side Shear Results

K1: 0.802

K2: 0.737894

Kb: 0

shear stress on side of channel: 3.13554 lb/ft²

Permissible shear stress for side of channel: 3.36459 lb/ft²

Stable Side D50: 0.547829 lb/ft²

side of channel is stable

Channel Lining Stability Results

the channel is stable

Channel Summary

Name of Selected Channel: WS 6 Channel Lining Calc

Channel Analysis: WS 8A Channel Lining Calc

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 5.0000 ft

Longitudinal Slope: 0.0238 ft/ft

Manning's n: 0.0580

Flow: 118.2400 cfs

Result Parameters

Depth: 2.3675 ft

Area of Flow: 23.0473 ft²

Wetted Perimeter: 15.5877 ft

Average Velocity: 5.1303 ft/s

Top Width: 14.4699 ft

Froude Number: 0.7164

Critical Depth: 1.9827 ft

Critical Velocity: 6.6517 ft/s

Critical Slope: 0.0484 ft/ft

Critical Top Width: 12.9309 ft

Calculated Max Shear Stress: 3.5160 lb/ft²

Calculated Avg Shear Stress: 2.1958 lb/ft²

Channel Lining Analysis: WS 8A Lining

Notes:

Lining Input Parameters

Channel Lining Type: Riprap, Cobble, or Gravel

D50: 0.67 ft

Riprap Specific Weight: 165 lb/ft³

Water Specific Weight: 62.4 lb/ft³

Riprap Shape is Angular

Safety Factor: 1

Calculated Safety Factor: 1.11426

Lining Results

Angle of Repose: 41.5 degrees

Relative Flow Depth: 2.50445

Manning's n method: Blodgett

Manning's n: 0.0658795

Channel Bottom Shear Results

V*: 1.38979

Reynold's Number: 76512.7

Shield's Parameter: 0.070505

shear stress on channel bottom: 3.74306 lb/ft²

Permissible shear stress for channel bottom: 4.84666 lb/ft²

channel bottom is stable

Stable D50: 0.576561 ft

Channel Side Shear Results

K1: 0.802

K2: 0.737894

Kb: 0

shear stress on side of channel: 3.74306 lb/ft²

Permissible shear stress for side of channel: 3.57632 lb/ft²

Stable Side D50: 0.626651 lb/ft²

side of channel is stable

Channel Lining Stability Results

the channel is stable

Channel Summary

Name of Selected Channel: WS 8A Channel Lining Calc

Channel Analysis: WS 10 Channel Lining Calc

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 5.0000 ft

Longitudinal Slope: 0.0167 ft/ft

Manning's n: 0.0634

Flow: 135.5400 cfs

Result Parameters

Depth: 2.8813 ft

Area of Flow: 31.0099 ft²

Wetted Perimeter: 17.8855 ft

Average Velocity: 4.3709 ft/s

Top Width: 16.5251 ft

Froude Number: 0.5623

Critical Depth: 2.1335 ft

Critical Velocity: 6.8554 ft/s

Critical Slope: 0.0568 ft/ft

Critical Top Width: 13.5340 ft

Calculated Max Shear Stress: 3.0025 lb/ft²

Calculated Avg Shear Stress: 1.8068 lb/ft²

Channel Lining Analysis: WS 10 Lining

Notes:

Lining Input Parameters

Channel Lining Type: Riprap, Cobble, or Gravel

D50: 0.67 ft

Riprap Specific Weight: 165 lb/ft³

Water Specific Weight: 62.4 lb/ft³

Riprap Shape is Angular

Safety Factor: 1

Calculated Safety Factor: 1.0893

Lining Results

Angle of Repose: 41.5 degrees

Relative Flow Depth: 2.80079

Manning's n method: Blodgett

Manning's n: 0.0634039

Channel Bottom Shear Results

V*: 1.24474

Reynold's Number: 68527.2

Shield's Parameter: 0.0653644

shear stress on channel bottom: 3.00252 lb/ft²

Permissible shear stress for channel bottom: 4.49328 lb/ft²

channel bottom is stable

Stable D50: 0.487692 ft

Channel Side Shear Results

K1: 0.802

K2: 0.737894

Kb: 0

shear stress on side of channel: 3.00252 lb/ft²

Permissible shear stress for side of channel: 3.31556 lb/ft²

Stable Side D50: 0.530062 lb/ft²

side of channel is stable

Channel Lining Stability Results

the channel is stable

Channel Summary

Name of Selected Channel: WS 10 Channel Lining Calc

Channel Analysis: WS 15 Diversion Channel Lining Calc

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 3.0000 ft

Longitudinal Slope: 0.0208 ft/ft

Manning's n: 0.0714

Flow: 55.5100 cfs

Result Parameters

Depth: 2.1687 ft

Area of Flow: 15.9125 ft²

Wetted Perimeter: 12.6987 ft

Average Velocity: 3.4884 ft/s

Top Width: 11.6748 ft

Froude Number: 0.5266

Critical Depth: 1.5665 ft

Critical Velocity: 5.7778 ft/s

Critical Slope: 0.0814 ft/ft

Critical Top Width: 9.2660 ft

Calculated Max Shear Stress: 2.8148 lb/ft²

Calculated Avg Shear Stress: 1.6264 lb/ft²

Channel Lining Analysis: WS 15 Lining

Notes:

Lining Input Parameters

Channel Lining Type: Riprap, Cobble, or Gravel

D50: 0.67 ft

Riprap Specific Weight: 165 lb/ft³

Water Specific Weight: 62.4 lb/ft³

Riprap Shape is Angular

Safety Factor: 1

Calculated Safety Factor: 1.0825

Lining Results

Angle of Repose: 41.5 degrees

Relative Flow Depth: 2.03431

Manning's n method: Blodgett

Manning's n: 0.0714151

Channel Bottom Shear Results

V*: 1.2052

Reynold's Number: 66350.3

Shield's Parameter: 0.063963

shear stress on channel bottom: 2.81479 lb/ft²

Permissible shear stress for channel bottom: 4.39694 lb/ft²

channel bottom is stable

Stable D50: 0.464299 ft

Channel Side Shear Results

K1: 0.802

K2: 0.737894

Kb: 0

shear stress on side of channel: 2.81479 lb/ft²

Permissible shear stress for side of channel: 3.24448 lb/ft²

Stable Side D50: 0.504636 lb/ft²

side of channel is stable

Channel Lining Stability Results

the channel is stable

Channel Summary

Name of Selected Channel: WS 15 Diversion Channel Lining Calc

Channel Analysis: WS 17 Diversion Channel Lining Calc

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 5.0000 ft

Longitudinal Slope: 0.0141 ft/ft

Manning's n: 0.0614

Flow: 165.5700 cfs

Result Parameters

Depth: 3.2504 ft

Area of Flow: 37.3817 ft²

Wetted Perimeter: 19.5361 ft

Average Velocity: 4.4292 ft/s

Top Width: 18.0015 ft

Froude Number: 0.5417

Critical Depth: 2.3719 ft

Critical Velocity: 7.1639 ft/s

Critical Slope: 0.0519 ft/ft

Critical Top Width: 14.4877 ft

Calculated Max Shear Stress: 2.8598 lb/ft²

Calculated Avg Shear Stress: 1.6835 lb/ft²

Channel Lining Analysis: WS 17 Lining

Notes:

Lining Input Parameters

Channel Lining Type: Riprap, Cobble, or Gravel

D50: 0.67 ft

Riprap Specific Weight: 165 lb/ft³

Water Specific Weight: 62.4 lb/ft³

Riprap Shape is Angular

Safety Factor: 1

Calculated Safety Factor: 1.08415

Lining Results

Angle of Repose: 41.5 degrees

Relative Flow Depth: 3.09939

Manning's n method: Blodgett

Manning's n: 0.0614048

Channel Bottom Shear Results

V*: 1.2148

Reynold's Number: 66878.8

Shield's Parameter: 0.0643032

shear stress on channel bottom: 2.85981 lb/ft²

Permissible shear stress for channel bottom: 4.42033 lb/ft²

channel bottom is stable

Stable D50: 0.469945 ft

Channel Side Shear Results

K1: 0.802

K2: 0.737894

Kb: 0

shear stress on side of channel: 2.85981 lb/ft²

Permissible shear stress for side of channel: 3.26173 lb/ft²

Stable Side D50: 0.510772 lb/ft²

side of channel is stable

Channel Lining Stability Results

the channel is stable

Channel Summary

Name of Selected Channel: WS 17 Diversion Channel Lining Calc

Channel Analysis: WS 10 Channel End of Apron

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 2.0000 ft/ft

Side Slope 2 (Z2): 2.0000 ft/ft

Channel Width: 31.6700 ft

Longitudinal Slope: 0.0100 ft/ft

Manning's n: 0.0350

Flow: 135.5400 cfs

Result Parameters

Depth: 0.9961 ft

Area of Flow: 33.5322 ft²

Wetted Perimeter: 36.1248 ft

Average Velocity: 4.0421 ft/s

Top Width: 35.6545 ft

Froude Number: 0.7345

Critical Depth: 0.8146 ft

Critical Velocity: 4.9968 ft/s

Critical Slope: 0.0197 ft/ft

Critical Top Width: 34.9284 ft

Calculated Max Shear Stress: 0.6216 lb/ft²

Calculated Avg Shear Stress: 0.5792 lb/ft²

Channel Analysis: WS 10 Channel @ Pond

Notes:

Input Parameters

Channel Type: Trapezoidal

Side Slope 1 (Z1): 5.0000 ft/ft

Side Slope 2 (Z2): 5.0000 ft/ft

Channel Width: 35.0000 ft

Longitudinal Slope: 0.0100 ft/ft

Manning's n: 0.0350

Flow: 135.5400 cfs

Result Parameters

Depth: 0.9193 ft

Area of Flow: 36.4013 ft²

Wetted Perimeter: 44.3751 ft

Average Velocity: 3.7235 ft/s

Top Width: 44.1930 ft

Froude Number: 0.7230

Critical Depth: 0.7473 ft

Critical Velocity: 4.6819 ft/s

Critical Slope: 0.0204 ft/ft

Critical Top Width: 42.4734 ft

Calculated Max Shear Stress: 0.5736 lb/ft²

Calculated Avg Shear Stress: 0.5119 lb/ft²

APPENDIX F – RIPRAP APRON ANALYSIS RESULTS



M3-PN160076
29 AUG 2016
Revision 2

Computation Sheet

Client: Excelsior Mining
 Project: Gunnison PFS
 Project No.: 160076
 Subject: WS 10 Riprap Apron

Made By: A Edwards
 Date: 8/16/2016
 Checked By: C Hunt
 Date: 8/16/2016

Riprap Apron Sizing Calculations

SI Units (Y or N) **N**

DETERMINE RIPRAP D50

D₅₀

Culvert/Channel Discharge, Q, in cfs or cms

Q = 135.54 cfs

Culvert/Channel Width or Diameter, D₀, in feet or meters

D₀ = 5.000 ft

Culvert/Channel Normal Flow, Y₀, in feet or meters

Y₀ = 2.15 ft

Culvert/Channel Flow Area, A, in sq. ft or sq. m

A = 20.030 sq. ft

Tailwater Depth, TW, in feet or meters

TW = 2.50 ft

Gravitational Acceleration, in m/s² or ft/s²

g = 32.2 ft/s²

Calculate D50

$$D_{50} = 0.2 D \left(\frac{Q}{\sqrt{g} D^{2.5}} \right)^{\frac{4}{3}} \left(\frac{D}{TW} \right)$$

D₅₀ = 0.64 ft

SIZE THE APRON

Table 10.1. Example Riprap Classes and Apron Dimensions

Use Table 10.1 for D50 determined

Class	D ₅₀ (mm)	D ₅₀ (in)	Apron Length ¹	Apron Depth
1	125	5	4D	3.5D ₅₀
2	150	6	4D	3.3D ₅₀
3	250	10	5D	2.4D ₅₀
4	350	14	6D	2.2D ₅₀
5	500	20	7D	2.0D ₅₀
6	550	22	8D	2.0D ₅₀

¹D is the culvert rise.

Riprap D50 Used	0.67	ft
Riprap Class	3	
Apron Length, in feet or meters	L _A = 25.000	ft
Minimum Apron Depth, in feet or meters	D _A = 1.608	ft
Width of Apron, in feet or meters	W _A = 31.667	ft

$$W_A = 3D_0 + (2/3)L_A$$

APPENDIX G – HEC-RAS ANALYSIS RESULTS



M3-PN160076
29 AUG 2016
Revision 2

HEC-RAS Plan: 100yr Interp River: OffsiteWash1 Reach: Offsite Wash 1 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Offsite Wash 1	2300	PF 1	111.25	4781.36	4782.07	4782.02	4782.25	0.018019	3.46	32.18	68.07	0.89
Offsite Wash 1	2200	PF 1	111.25	4778.97	4779.95	4779.95	4780.19	0.023684	3.97	28.04	59.20	1.02
Offsite Wash 1	2000	PF 1	111.25	4774.16	4775.00	4775.03	4775.29	0.025292	4.35	25.59	49.47	1.07
Offsite Wash 1	1600	PF 1	111.25	4765.79	4766.80	4766.80	4767.11	0.021871	4.48	24.86	41.24	1.02
Offsite Wash 1	1450	PF 1	150.50	4762.40	4763.58	4763.44	4763.79	0.011814	3.72	40.43	55.74	0.77
Offsite Wash 1	1350	PF 1	150.50	4761.35	4762.32	4762.22	4762.51	0.013657	3.48	43.30	73.79	0.80
Offsite Wash 1	1100	PF 1	168.00	4757.20	4757.79	4757.79	4758.00	0.024090	3.71	45.23	106.84	1.01
Offsite Wash 1	1000	PF 1	168.00	4754.56	4755.52	4755.39	4755.68	0.011580	3.27	51.42	85.00	0.74
Offsite Wash 1	900	PF 1	168.00	4753.03	4753.85	4753.85	4754.08	0.023580	3.82	44.00	98.15	1.00

CRAI Comment 38

38. A.A.C. R18-9-A202(A)(5)(a) - For each impoundment, please provide a basis and calculations that determined the volumes presented in Tables 2.1, 3.1, 4.1, 5.1, 6.1, and 7.1 in Appendix K of Volume III. Include water balance calculations to account for all inflows and outflows including the 100-year, 24-hour storm. Please explain why the ponds are designed for only 8-hour process volumes and provide a justification. For the Plant Runoff Pond, provide the estimated volume of accidental discharge from other process solution ponds and include this volume in the water balance.

ADEQ Evaluation

The response to RAI 38 is **not** adequate.

Excelsior had previously included an additional 20% volume to provide operational flexibility. Though the additional 20% volume was considered desirable, it was not specifically required. In place of the 20% additional volume, Excelsior provided the additional volume required for a 100-year, 24-hour storm event. Excelsior provided revised tables in the revised Appendix K provided in response to this comment.

The Evaporation Pond previously proposed for Stage 2 and 3 has been proposed to be used in Stage 1 and has been renamed as Evaporation Pond #1. In the future, Excelsior may add another evaporation pond (Evaporation Pond #2) under an amendment to the permit.

Revised drawings showing contours, v-ditches, and diversion ditches were provided in the revised Appendix K (these were not presented in the original Appendix K).

A mathematical error was identified for the Solids Impoundment (Table 5.1, page K-21) in which the Total Volume Required (ft³) was presented as 15,204,180, while the total of the Accumulated 60% Precipitate Slurry Volume (13,872,750), Design Storm Volume (217,800), and Two Feet Freeboard Volume (1,203,630) is 15,294,180 ft³. Please resubmit the revised calculations, or alternatively acknowledge typographical error.

RESPONSE

The Total Volume Required for each Solids Impoundment amounts to 15,294,180 ft³. The volume of 15,204,180 ft³ presented in Table 6.1, page K-27 is a typographical error.

39. **ADEQ COMMENT:** A.A.C. R18-9-A202(A)(5)(a) - Please provide the locations of all borings (abandoned wells, boreholes, etc.) located within the footprint and within 150-feet of the perimeter of each pond. All borings must be properly plugged in order to prevent the potential migration of impoundment fluids due to liner failure.

ADEQ Evaluation

The response to RAI 39 is **not** adequate.

Excelsior indicated that there are a total of four wells within 150 feet of the perimeter of the PLS Pond. Information related to the four wells was provided. However, the information does not match the ADWR records (well depth, casing depth, and casing diameter). See screenshots below.

Also, Excelsior did not state that they would abandon the wells found within 150 feet of the perimeter of the pond.

Please correct the information for the wells as per ADWR records, and indicate which wells, if any, are planned to be abandoned.

Excelsior Response to Comment 39

ADWR Registry ID	CADASTRAL	Well Name	Owner	Well Type	Depth (ft)	Casing Depth (ft)	Casing Diameter (in)	Latitude	Longitude
224035	D(15-23) 31CAD	NSH-020	EXCELSIOR MINING CORP	ENV - MONITOR OR PIEZOMETER	1600	1582	4.5	32.08374886	-110.038526
224101	D(15-23) 31CAD		EXCELSIOR MINING CORP	ENV - MONITOR				32.08406809	-110.0387882
224100	D(15-23) 31CAD	NSH-018	EXCELSIOR MINING CORP	ENV - MONITOR OR PIEZOMETER	997	992	4.5	32.08419361	-110.0385209
917777	D(15-23) 31CDA	NSH-029	EXCELSIOR MINING CORP	ENV - MONITOR OR PIEZOMETER	710	709	2.375	32.08296473	-110.0385398

Data from Arizona Department of Water Resources Well Registry Database

ADWR Website

Reg No.	GWSI Site ID	Cadastral	Owner Name	Well Type	Well Depth (ft)	Casing Depth (ft)	Case Dia (in)
17777		D15023031CDA	EXCELSIOR MINING CORP	MONITOR			
24101		D15023031CAD	EXCELSIOR MINING CORP	MONITOR			
24035		D15023031CAD	EXCELSIOR MINING CORP	MONITOR	710	700	7
24100		D15023031CAD	EXCELSIOR MINING CORP	MONITOR	997	960	4

EXCELSIOR RESPONSE:

The four wells listed are confirmed to be within 150-feet of the pond based on Excelsior location data. An updated table of the well information is provided below.

ADWR Registry ID	Cadastral	Well Name	Owner	Well Type	Depth (ft)	Casing Depth (ft)	Casing Diameter (in)	Latitude	Longitude
224035	D(15-23) 31CAD	NSH-020	EXCELSIOR MINING CORP	ENV - MONITOR OR PIEZOMETER	710	700	2.375/4.5	32.08374886	-110.038526
224101	D(15-23) 31CAD	DID NOT DRILL							
224100	D(15-23) 31CAD	NSH-018	EXCELSIOR MINING CORP	ENV - MONITOR OR PIEZOMETER	997	960/992	4.5	32.08419361	-110.0385209
917777	D(15-23) 31CDA	NSH-029	EXCELSIOR MINING CORP	ENV - MONITOR OR PIEZOMETER	710	709	2.375	32.08296473	-110.0385398
Data from ADWR Well Registry Database and Excelsior Records									
ft= feet									
in=inches									

The information in the table was reviewed and corrected based on ADWR imaged records. Changes are summarized below:

- 55-224035 Depth was changed from 1,600 feet (ft) to 710 ft. The lithologic log included in the ADWR imaged record has a depth of 1,600 feet listed. Other parts of the imaged records including the Driller's report and As-Built drawing indicated a depth of 710 feet. The casing diameter is listed in the ADWR database as 7 inches. The as-built drawing in the imaged records lists casing diameters of 2.375 and 4.5 inches.
- 55-224101: Well was not drilled according to ADWR imaged record, the table was changed to reflect that.
- 55-224100: The ADWR database lists the casing depth as 960 ft. The imaged record shows a depth of 960 ft on the driller's report and 992 on the as-built. Both depths are included in the updated table. The driller's report and as-built drawing list the casing diameter as 4.5 inches so that was not changed on the updated table.
- 55-917777: Well information was provided by Excelsior. No information is available in the imaged record. The updated table was not modified for this well.

The three existing wells will be abandoned prior to construction of the pond.

CRAI Comment 40

40. A.A.C. R18-9-A202(A)(5)(a) - Please provide a Quality Assurance/Quality Control (QA/QC) Plan including all BADCT elements.

ADEQ Evaluation

*The response to RAI 40 is **not** adequate.*

Excelsior provided a QA/QC plan prepared by Paul Axelrod. The document was not sealed. This document shall be sealed by an Arizona registered professional engineer.

RESPONSE

The sealed document is attached.

GUNNISON COPPER PROJECT IMPOUNDMENT CONSTRUCTION - QA/QC PLAN

Prepared for:



2999 North 44th Street, Suite 300
Phoenix, Arizona 85018

Prepared by:

Axelrod, Inc.
P.O. Box 14401
Scottsdale, Arizona 85267

Project No. 216100
July 2016

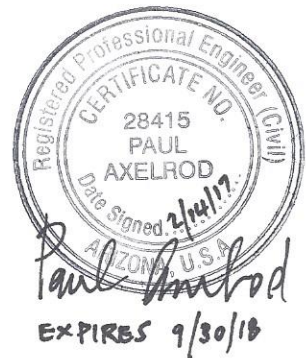


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TABLES

Table 1 – QA/QC Testing Requirements – Earthworks

Table 2 – ASTM Procedures

CONSTRUCTION QUALITY ASSURANCE / QUALITY CONTROL PLAN

1.0 INTRODUCTION

This Construction Quality Assurance / Quality Control (QA/QC) Plan is provided as a guide to field and laboratory personnel conducting QA/QC inspection and testing for the construction of the impoundments for the Gunnison Copper Project. Standard procedures will be used for all activities and in general they will be those adopted by recognized organizations, such as American Society of Testing and Materials (ASTM).

QA/QC procedures including testing, inspecting and reporting are necessary to ensure that materials, construction and installation of the impoundment components meet or exceed all design criteria, drawings and specifications. This document shall be used in conjunction with the design Drawings, Technical Specifications, relevant standards and codes.

2.0 ORGANIZATION AND RESPONSIBILITIES

The Owner of the Gunnison Project is Excelsior Mining Arizona, Inc. (Excelsior). It is anticipated that Excelsior will appoint a Construction Manager (CM) and QA inspection and testing company for the project. M3 Engineering is the impoundment designer and Engineer.

The contractor and in the case of geosynthetics, the manufacturer and installer, are responsible for QC which includes testing and activities to ensure that materials being produced and installed are as specified. QA involves check testing and inspection during construction to assure the constructed items meet the design documents, intent and criteria.

Construction items for the project include earthwork, concrete and geosynthetic materials. The QA/QC programs for earthwork and concrete will entail construction inspection and check testing of materials. The geosynthetic liner contractor will perform QC testing for the liner, which consists of destructive tests on liner seam samples and air and vacuum testing of the panel seams. The QA testing will include observation of the liner installation and the contractor's QC tests.

Excelsior will perform the function of overall Project Manager. The CM's function is to ensure that the project is constructed in accordance with the project documentation. The QA/QC services include completing and recording (as detailed in this report) all testing and inspection for the project. The completed test results will be submitted to the CM. The CM will report directly to Excelsior while the QA/QC personnel will report to the CM.

The QA testing does not relieve the Contractor of liability for sub-standard work. In addition to the QC testing and inspection, the Contractor is responsible for setting out correct lines and grades, ensuring that

the work is constructed to them. Third party surveyors will check the lines and grades.

3.0 STATEMENT OF QUALIFICATIONS OF QA/QC PERSONNEL

The training and experience of the QA/QC personnel must demonstrate their ability to fulfill their assigned responsibilities. The Technical Specifications require that the geomembrane installer list at least three completed projects where they installed a minimum of 200,000 square feet of HDPE and one project where they installed a minimum of one million square feet of HDPE.

4.0 TECHNICAL SPECIFICATIONS

The Technical Specifications for the project will be prepared by M3 and presented in a document titled "Gunnison Impoundments - Technical Specifications"

5.0 STANDARD PROCEDURES

5.1 SAMPLING

Sample identification will contain the following information.

1. Project name and number
2. Material type
3. Sample number and location
4. Date
5. Initials of sampler

The following general procedure will be used, modified as appropriate for the sample type and purpose.

- Collect samples in accordance with the technical specifications when applicable
- Collect an adequate, representative sample
- Transport and handle it to avoid possible contamination
- Accept samples only after checking for identification and integrity
- Retain or dispose of samples as directed by the construction manager

It is not anticipated that custody procedures will be necessary but they will be developed if required.

5.2 DOCUMENTATION

The QA/QC personnel will maintain records of all tests. Individual test data and results will be recorded on a standard form applicable to the test being performed. The location of all tests will be accurately described. The QA/QC personnel will maintain a plan, showing the position of the tests. Daily summaries of tests and results are recommended for tracking purposes.

All entries on all documents are to be indelible ink. Erroneous information must not be covered. Date and initial corrections.

5.3 MATERIAL PREAPPROVED

All “or equal/equivalent” materials must be approved by the Engineer. Prior to construction, obtain schedules of properties for all materials fabricated or manufactured off site.

6.0 INSPECTION AND TESTING

Classification and testing of soil, concrete and liner materials will conform to the ASTM procedures, where applicable. The ASTM procedures anticipated for this project are shown in Table 2:

The testing and inspection required for the construction of the impoundments is as follow:

6.1 EARTHWORKS

The earthworks section includes site clearing, excavation, subgrade preparation, structural fill, pipe backfill, drainage and liner bedding materials.

6.1.1 Site Clearing

The surface of construction areas will be visually checked for adequate removal of growth media and major root zones in accordance with the Technical Specifications. Check that unsuitable materials are fully cleared from the construction area.

6.1.2 Excavation

Excavated areas will be visually checked for conformance to the Drawings and Specifications. The Contractor and the CM are responsible for the impoundment layouts and dimensions.

6.1.3 Subgrade Preparation

The subgrade in areas to receive fill will be scarified, moisture conditioned and compacted to the specified density. Check the subgrade density and visually inspect the area to verify conformance to the Technical Specifications. Field and laboratory test results will be reported on a summary form. Perform subgrade density testing in areas where soil type material is the final subgrade surface. No density testing is required in those areas where the subgrade material is excavated into rock. The frequency and type of subgrade testing is listed in Table 1. Perform sieve analyses and Atterberg Limit tests for each material type or at the frequency listed in Table 1. Locations of all tests will be marked on a site plan.

Where tests have failed to comply with the specifications, additional testing will be performed to determine the extent of unsuitable material. When the limits of the failing testing area have been determined, the material will be moisture conditioned and re-compacted until the required density is obtained. All subgrade is to be accepted in writing by the QA/QC personnel.

6.1.4 Structural Fill

Structural fill will be used for the impoundment embankments. It is anticipated that the fill will be obtained from the impoundment excavations.

Laboratory density and indicator testing are required on the material prior to placement, to determine its suitability and to check in place density. The testing frequencies are listed in Table 1 and for laboratory tests should be at least one per material type.

A summary of all test results will be periodically supplied to Excelsior and M3 for their review.

The fill placement will be monitored on an incremental basis and lift thickness checked. No additional fill lifts will be approved for placement prior to the existing lift being observed and tested with passing results. Nuclear density testing will be performed at randomly selected locations for each lift of fill placed and at the frequency listed in Table 1. Sand cone field density tests are required periodically to check the calibration of the nuclear density gauge.

Where tests have failed to comply with the Project Specifications, additional field and laboratory tests will be performed to determine the extent of unsuitable material. When the limits of the failing testing area have been determined, the material will be moisture conditioned and re-compacted until the required density is obtained.

6.1.5 Pipe Backfill

Pipe backfill will be used as bedding below and cover around pipes and for liner anchor trenches, as shown on the Drawings. Backfill will be inspected for layer thickness and tested for density and grain size distribution. Test frequency is noted in Table 1. Maintain a summary of all test results.

6.1.6 Drain Rock

Drain rock will be placed in the sump area of the pond leak detection and recovery system. Inspect these materials for grain size distribution. Samples will be retrieved for testing at the frequency listed in Table 1. Record all test results on a summary sheet.

6.1.7 Liner Bedding Material

Liner bedding is required for the HDPE lined impoundments. The bedding material shall be obtained from on or off-site locations, as required. Inspect layer thickness and finished surface for smoothness and shape, as specified in the Technical Specifications.

Test requirements are as for structural fill, and include laboratory density, sieve analysis and Atterberg Limits, and field density and moisture content. Frequency of tests per Table 1. Maintain a list of all test results on a summary form. All liner bedding is to be accepted in writing by the Contractor and QC personnel.

6.2 CONCRETE

Concrete inspections include: compliance with Drawings and Technical Specifications; reinforcing size, spacing, alignment and cover; form dimensions; casting surface cleanliness, and treatment of construction joints. Vibration of the concrete during placement, surface finish and curing will also be inspected.

Submit concrete supplier's mix design to the Engineer for review prior to placement of concrete. Four standard concrete cylinders shall be prepared for each pour or at the frequency listed in Table 1. Slump and air entrainment tests will be performed at the time the cylinders are prepared.

All mixed concrete delivered to the site shall be placed within 90 minutes from the time of the introduction of cement and water into the mix.

List all concrete test results and location of pours on a summary sheet.

6.3 GEOSYNTHETICS

Geosynthetic materials include geotextile, geonet and HDPE geomembrane liner. Prior to installing any geosynthetic materials, the supplier shall provide the QA/QC personnel with the information listed in the Technical Specifications. QC testing shall be carried out by the geosynthetics manufacturers to demonstrate that the products meet the requirements of the Technical Specifications. Once the geosynthetic material has been delivered and logged in, the QA/QC personnel shall verify that the materials delivered meet the Technical Specifications and match those which are on the bill of lading. Any discrepancies between the Technical Specifications and the material delivered shall be reported to the CM.

6.3.1 Geotextile

Installation of the geotextile shall be planned such that it does not cause damage to the subgrade or geomembrane, is anchored as soon as possible and is kept clean. Geotextile shall be inspected after installation for defects, damage, continuity of seams, overlap and shingling. Holes in the geotextile are to be patched in accordance with the Technical Specifications.

6.3.2 HDPE Liner

A sample of each batch of liner shall be taken prior to deployment. The samples shall be used for verification of properties as listed in the Technical Specifications. Inspect all liner bedding material surfaces prior to deployment for sharp edged protrusions that could damage the liner. The HDPE installation and liner contractor's quality control shall be monitored. All testing shall be in accordance with the Technical Specifications. Check the liner contractor's quality control for trial seams and liner seams to ensure that each seam has been fully tested and that the test results meet the applicable specified standards. Seam strength testing shall be done as the seaming work progresses

and not at the completion of all field seaming. Seams and HDPE panels are to be labeled by the contractor, in accordance with manufacturer sheet numbers, and the numbering recorded by QA/QC personnel on inspection forms and a panel layout drawing.

The liner contractor's quality control shall include destructive testing of the seam samples recovered from the installed material at the frequency listed in the specifications. Observe all destructive tests. Duplicates of the samples shall be obtained both for testing by an independent laboratory and for Excelsior to retain for their record.

Inspect the completed liner surface for defects. Record the location of all repairs.

6.3.3 Geonet

Installation of the geonet shall be planned such that it does not cause damage to the geomembrane, is anchored and is kept clean. Geonet shall be inspected after installation by the QA/QC personnel for defects, damage and continuity. Gaps in the geonet are to be patched in accordance with the Technical Specifications.

6.4 PIPEWORK

Conduct visual inspection of all welds, particularly butt-welded HDPE pipe. Tests to be conducted as laid out in the Technical Specifications.

6.5 FAILING TESTS

Where tests have failed to comply with the specifications, additional QA testing will be performed to determine the extent of unsuitable material. When the limits of the failing testing area have been determined, the material will be appropriately treated to comply with the Technical Specifications.

7.0 REPORTS

The QA/QC personnel will prepare a report after each site visit summarizing the work inspected, tests performed and other relevant items. The report will indicate any failed inspections or tests, the actions taken to rectify these, and reports received or given about unacceptable or substandard procedures or materials. On completion of work all inspection and testing will be summarized in a final report suitable for agency review and Excelsior documentation.

TABLE 1
GUNNISON IMPOUNDMENTS
QA/QC TESTING REQUIREMENTS - EARTHWORKS

Material Type	Unit	Minimum Frequency (No. of Units Per Test)			
		Field Density	Laboratory Sieve Analyses	Laboratory Atterberg Limits	Laboratory Moisture-Density Relation
Subgrade	s.f.	10,000	100,000	100,000	200,000 or 1/matl. type
Structural Fill	c.y.	3,000 40,000*	10,000	10,000	15,000 1/matl. type
Drain Rock	c.y.	0	100 1/matl. type	0	0
Liner Bedding Material	c.y.	200	1000 1/matl. type	1000 1 min	5000 1/matl. type
Pipe Backfill	c.y.	100	400	400	1/matl. type

* Sand cone test

CONCRETE TESTING

- Prepare concrete cylinders for each 50 cy of concrete poured or for each pour if less than 50 cy is poured at one time.
- Four cylinders required for compressive tests at 7, 14, and 28 days and one spare.
- Perform slump, air content and temperature at the time cylinders are prepared.

GEOSYNTHETICS

Testing as per Technical Specifications

TABLE 2
GUNNISON IMPOUNDMENTS
ASTM PROCEDURES

Test Type	ASTM Procedure
Field Density – Nuclear Gauge	D 2922
Field Density – Sand Cone	D 1556
Field Moisture – Nuclear Gauge	D 3017
Laboratory Moisture	D 2216 or D 4643
Laboratory Moisture - Density Relation	D 698
Grain-Size Analysis	D 422
Plasticity Indices (Atterberg Limits)	D 4318
Concrete Aggregate Sampling	D 75
Concrete Slump	C 172
Concrete Air Content	C 138 or C 231
Concrete Compressive Strength	C 39

Volume I - Section 7.1.5 Wellfield Closure Strategy [A.A.C. R18-9-A202(A)(10)]:

CRAI Comment

42. This section does not indicate when the Stage 1 wells will be abandoned; i.e. whether they are abandoned as the rinsing for a given 5-spot is completed demonstrating that concentrations of all constituents are at or below acceptance criteria (as stated in Appendix M), or at the end of Stage 1. Provide a detailed closure strategy including the schedule of abandoning the wells as mining activities progress.

ADEQ Evaluation

The response to RAI 42 is **not** adequate.

Wells will be plugged and abandoned after rinsing of a mine block is complete. There is no plan to wait until the end of Stage 1 to plug and abandon wells.

In general, wells that begin leaching operation a given year will be ready for abandonment in Year 8 (Four years of leaching, early stage rinsing in Year 5, one year rest period in Year 6, late stage rinsing in Year 7, and abandonment in Year 8). In some cases wells located adjacent to a mine block may not be immediately abandoned and instead may be used for observation purposes.

Excelsior must provide an evaluation of the mine plan to ensure no wells are abandoned prematurely and adjust closure costs as necessary. For example, based upon Figure 8-1, mining may be taking place upgradient of year 1 and other earlier years mining. While the year 1 mine location may have been rinsed, relaxed and rinsed again, potential “PLS” may become present again in the year 1 mine location.

EXCELSIOR RESPONSE:

Excelsior has revised the closure strategy for the wellfield to address ADEQ’s concern that wells may be abandoned prematurely or that mining upgradient of a block that has already been rinsed will be impacted with PLS. The revised closure plan is provided in the revised BADCT demonstration in Comment 16. A map (Figure 16-16) in the BADCT demonstration that shows the density of wells that will be retained as “Rinse Verification Wells” (RVWs) (approximately 1 for every 1.5 acres) and “Closure Verification Wells” (CVWs) (approximately 1 well for every 13.5 acres.). An appropriate number of RVWs will be used as post-rinse IMWs to identify possible migrations of mining fluids from adjacent active mining areas back into previously rinsed mining blocks. The locations and distribution of these IMWs will be determined using the general principles outlined in Excelsior’s response to comment 2.

Prior to well plugging and abandonment (of wells that will not be used as RVWs, IMWs, or CVWs) in a mining block, a report will be submitted to ADEQ documenting the rinsing verification data. The report will include documentation of the volumes of rinse water injected and recovered, results of laboratory analytical analyses after Step 3, and a

recommendation will be provided on whether additional rinsing is needed. Well plugging and abandonment will not commence without approval from ADEQ and USEPA.

Because the abandonment of some wells will be delayed according to the revised closure plan (so that they can be used as IMWs/RVWS/CVWs), Excelsior will revise Appendix M to reflect the changes in annual closure costs. The revised closure costs will provide a revised schedule for well abandonment.

An appropriate number (a subset) of RVWs will be selected as post-rinse IMWs. Their purpose is to identify possible migration of mining fluids from adjacent active mining areas back into previously-rinsed mining blocks. These post-rinse IMWs will be continuously monitored for water elevation and specific conductivity. Ambient specific conductivities in these wells, which reflect the post-rinsing groundwater chemistry that meets AWQs and MCLs will be established. Even though the ambient specific conductivity at these wells will be elevated, they will still be appropriate monitoring points for detection of PLS. Alert Levels will be set for post-rinse IMWs using 2 months of specific conductance measurements. If the Alert Level is triggered, If an Alert Level for specific conductance is exceeded, Excelsior will develop a plan of action within 30 days. as described in the response to Comment 2.

Selection of the former injection and recovery wells to serve as post-rinse IMWs will be based on their connections to major hydraulically-conductive fractures, as demonstrated during the operation of the wellfield. Because these wells will already have been used for four years of leaching/recovery, the degree of connection will be well understood. Excelsior will propose to ADEQ and EPA the wells that will be used as IMWs after rinsing after the first year of rinsing of the block.

CRAI Comment

43. *According to Volume 1, Section 7.1.5.1, page 12, a sample size of “approximately 10% of the wells within the mining block” will be monitored to determine the effectiveness of groundwater rinsing. Please provide the rationale, including references, for selection of this sample size. ADEQ believes that this is too low and that all wells within the PMA should be monitored to determine the effectiveness of rinsing.*

ADEQ Evaluation

The response to RAI 43 is **not** adequate.

Excelsior indicated that during the project life there will be 1,400 injection/recovery wells over 192 acres. The sampling of all wells is not reasonable due to the close spacing of the wells and due to the fact that many of the samples from injection wells would simply reflect collection of recently-injected clean rinse water.

Sampling of 10% wells equate to one well for every 1.4 acres. Excelsior considers this to be a high sample density that will adequately characterize the effectiveness of rinsing. Please see ADEQ Evaluation for response to RAI 16 Alternative 1, d.

EXCELSIOR RESPONSE:

In response to this comment, Excelsior revised the closure strategy for the wellfield to address ADEQ’s concern that wells may be abandoned prematurely or that mining upgradient of a block that has already been rinsed will be impacted with PLS. The revised closure plan is provided in the BADCT demonstration in Comment 16. A map (Figure 16-16) in the BADCT demonstration shows the density of “Rinse Verification Wells” (approximately 1 for every 1.5 acres,) and “Closure Verification Wells” (approximately 1 well for every 13.5 acres). Based on the close spacing of the wells, and due to the fact that samples from injection wells would reflect chemistry of the rinse water, the proposed closure/post closure monitoring plan is justifiable. Furthermore, because final closure will be contingent based on 5 consecutive years of meeting AWQSs and MCLs within the wellfield at CVWs, the revised closure strategy addresses concerns for potential rebound.

CRAI Comment

45. *ADEQ understands that in-situ leaching will occur in the oxide ore body which contacts the basin fill at varying elevations at the project site. The aquifer is within the basin fill where the contact between the basin fill and the oxide is below the water table. There may be a potential upward migration of injected fluids into the basin fill (refer to Comment No. ~~40~~ 27). Please include the closure costs for rinsing in the basin fill portions of aquifer which could contain injected fluids.*

ADEQ Evaluation

The response to RAI 45 is **not** adequate.

Excelsior indicated that they do not plan to rinse the basin fill since there will be no injection of solutions into the basin fill. Revised geologic cross-sections were provided in response to comment 26.

A bedrock ridge composed of limestone is present east of the wellfield. If groundwater is present in the basin fill, it will be neutralized as it flows through the limestone.

The revised Stage I Closure Costs were developed for 10 years using third party contractor costs. Closure costs for the Evaporation Pond #1 and Pipeline Drain Pond were also included. Costs included removal of mechanical evaporators, earthwork, dewatering, placement of geotextile for covering evaporation solids, rip-rap to protect surface drainages, and revegetation/reseeding of the pond surface after covering.

The closure costs took into account credits for closure work that would have been completed in a given year starting in Year 5. The maximum liability was identified in Year 8 in the amount of \$8.420 million.

Please include revised closure costs based upon comments to ADEQ's evaluation of RAI 8.a.ii.

EXCELSIOR RESPONSE:

Excelsior will revise closure costs based upon comments to ADEQ's evaluation of RAI 8.a.ii.

CRAI Comment

46. Under the header titled “Fixed Closure Costs”, the following statement was included:

“The maximum number of wells in operation in any year is 63 recovery wells and 42 injection wells...”

Does the above statement indicate that in the final year of Stage 1, there will be 42 injection wells and 63 recovery wells that will require closure? See Comment No. 35 below for additional questions regarding the number of wells planned for Stage 1.

ADEQ Evaluation

The response to RAI 46 is **not** adequate.

Excelsior provided a table of injection and recovery wells planned by each year for Stage 1. The table included well installed, closed and in rinse phase and indicated that Year 7 will have the maximum number of production wells comprised of injection and recovery wells.

Please see comments to ADEQ Evaluation of RAI 42.

EXCELSIOR RESPONSE:

Excelsior has revised the closure strategy for the wellfield to address ADEQ’s concern that wells may be abandoned prematurely or that mining upgradient of a block that has already been rinsed will be impacted with PLS. The revised closure plan is provided in the BADCT demonstration in Comment 16 and also addressed in the response to Comment 42.

Because the abandonment of some wells will be delayed according to the revised closure plan, Excelsior will revise Appendix M to reflect the changes in annual closure costs.

CRAI Comment

47. Under the header titled “Variable Closure Costs”, the following statement was included:

“Some of the wellfield closure costs are dependent on the number of wells that need to be rinsed and closed at any given point in time.”

- a. *Information relating to the number of wells included in evaluating the closure costs for Stage 1 was not evident in the application. Please provide an evaluation of closure costs based on the number of wells (injection, recovery, observation and hydraulic control wells) planned for closure in Stage 1.*

ADEQ Evaluation

The response to RAI 47 is **not** adequate.

Excelsior indicated that 200 wells are planned for Stage 1. The number of wells planned for closure in Year 10 is 48. The response states “no observation or hydraulic control wells are planned for closure in Stage 1 as they would be required in Stages 2 and 3; however, costs were included for closure of these wells (see Table M-1 in response to Comment 46).

Please see comments to ADEQ Evaluation of RAI 42.

EXCELSIOR RESPONSE:

Closure costs for wells were calculated year by year, based on the number of existing wells that year, regardless of the year they were installed or the year they are actually scheduled for abandonment. Excelsior will revise Appendix M because of the revised closure strategy.

Another statement under the same header, included:

“Water supply costs are based on the existing wells at the Johnson Camp Mine...”

- a. *Please provide information relating to the quantity of water available and quality of water proposed to be supplied by the wells at the JCM facility. Please note that if additional treatment would be required prior to use of the JCM water for rinsing, these costs should be detailed in the proposed closure costs.*

ADEQ Evaluation

The response to RAI 47a is adequate.

As presented in response to RAI 5, Excelsior provided the sources of clean water, and in relation to the quantity of water available, Excelsior provided pump capacities for various wells near the JCM site. Excelsior indicated that test results demonstrated that water from these wells meets AWQS and requires no additional treatment for use as rinse water during the post-production period.

b. Please provide the cost (power and any other associated costs) to inject the rinsate.

ADEQ Evaluation

The response to RAI 47b is **not** adequate.

Excelsior provided the following response.

“There is no power cost to inject rinsate. Water to rinse the depleted production comes from the existing water tank at the Johnson Camp Mine. The power cost to get water to the supply water tank is included in the Water Supply Cost line item (Line 25 in Table M-1 of revised Appendix M). Rinse water for the injection wells flows by gravity from the tank at an elevation of approximately 5,200 feet amsl to the well blocks that vary in elevation from approximately 4,850 to 4,800 feet amsl. This provides a head pressure of from 150 to 170 pounds per square inch, more than adequate for rinse injection.”

Please explain how gravity flow is adequate to inject the rinsate, assuming that the injected solutions during mining would require to be injected.

EXCELSIOR RESPONSE:

Leaching and rinsing flow rates will be significantly different, so that while injection will be under pressure, rinsing will be under gravity flow. During leaching, a fast flow rate is required so that the rocks do not neutralize the acid before it can be recovered. Under rinsing, this is not a concern. Furthermore during rinsing, which could be considered the opposite of production, slow flow rates give pollutants time to diffuse out of rocks. Because of the slower flow rates, pumps will be changed out between leaching and injection. Pump changeouts are included in the closure costs.

c. Please explain why verification sampling (Table M-7) will be conducted on only 10% of the recovery wells (see Comment No. 30 43).

ADEQ Evaluation

The response to RAI 47c is **not** adequate.

Excelsior provided the same response as that for RAI 43. Please refer to RAI 43, and RAI 16, Alternative 1, d.

EXCELSIOR RESPONSE:

From response to ADEQ evaluation 43: In response to this comment, Excelsior revised the closure strategy for the wellfield to address ADEQ’s concern that wells may be abandoned prematurely or that mining upgradient of a block that has already been rinsed will be impacted with PLS. The revised closure plan is provided in the BADCT demonstration in

Comment 16. A map (Figure 16-16) in the BADCT demonstration shows the density of “Rinse Verification Wells” (approximately 1 for every 1.5 acres), and “Closure Verification Wells” (approximately 1 well for every 13.5 acres). Based on the close spacing of the wells, and due to the fact that samples from injection wells would reflect chemistry of the rinse water, the proposed closure/post closure monitoring plan is justifiable. Furthermore, because final closure will be contingent based on 5 consecutive years of meeting AWQSs and MCLs within the wellfield at CVWs, the revised closure strategy addresses concerns for potential rebound.

- d. In Table M-7, please explain what the number “Recovery Wells Installed” represent for each year; i.e. does this mean that in each year up to Year 10, 480 recovery wells will be installed?*

ADEQ Evaluation

The response to RAI 47d is adequate.

Excelsior indicated that the information in Table M-7 was intended to represent the number of recovery (or injection) wells installed and put into production in each of the years of Stage 1 operation. By Year 10 there will be 152 injection/recovery wells (taking into account 48 of the 200 wells will be closed by Year 10). Of these 152 wells, 87 wells are expected to be in active production, 54 in active rinsing or resting, and 11 will be dormant, awaiting closure.

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Wells added by Year	38	20	20	17	21	16	18	20	14	16
Cumulative Total Wells	38	58	78	95	116	132	150	150	148	152
Wells closed by Year	0	0	0	0	0	0	0	20	16	12
Cumulative Total Closed	0	0	0	0	0	0	0	20	36	48

- e. In Table M-8, please provide the basis of the footage of the wells drilled in each year; i.e. number of injection wells, recovery wells, their depths, etc.*

ADEQ Evaluation

The response to RAI 47e is adequate.

In response to the above comment, Excelsior provided a table (see below) of injection and recovery wells planned for installation each year until Year 10. Average depth of wells in this Stage is anticipated to be 1,435 feet, so a depth of 1,450 feet was used to calculate well abandonment costs.

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	TOTAL
Injection wells new	14	9	8	7	9	8	8	9	6	8	86
Recovery wells new	24	11	12	10	12	8	10	11	8	8	114
Total new	38	20	20	17	21	16	18	20	14	16	200

- f. Please indicate at what stage the hydraulic control wells and the observation wells will be abandoned. If any are abandoned during Stage 1, please provide the number, type of wells, and the associated cost of abandonment.*

ADEQ Evaluation

The response to RAI 47f is adequate.

As indicated in response to Comment 47.a, there are no plans to abandon hydraulic control and observation wells at the end of Stage 1; however, costs to abandon have been included in Table M-1 (see response to Comment 45).

- g. Please include costs to pump all the hydraulic control wells necessary to maintain hydraulic control until final closure.*

ADEQ Evaluation

The response to RAI 47g is **not** adequate.

The closure costs account for Hydraulic Control Pumping for the year in question, plus three more years for rinsing. Please see comments to ADEQ Evaluation RAI 8.a.ii. and RAI 16, Alternative 1.

EXCELSIOR RESPONSE:

Excelsior is revising Appendix M closure costs to address the comments to the ADEQ evaluations referenced above.

CRAI Comment

50. *No post-closure costs have been provided. Please provide post-closure costs for monitoring and maintenance following the rinse period and the rationale for the duration of post-closure. Please provide a table which clearly shows the closure and post-closure costs by line items.*

ADEQ Evaluation

The response to RAI 50 is **not** adequate.

Please see ADEQ's responses to RAI 8.b and RAI 16 Alternative 1, e.

Excelsior provided the following response.

"Excelsior has proposed that rinsing verification monitoring be conducted at 10% of the wellfield injection/recovery wells after the late rinsing stage (see responses to comment 43 and 47c). After numerical AWQs are achieved, the injection/recovery wells will be abandoned."

Excelsior proposed a longer post-closure monitoring period of 5 years as opposed to the originally proposed four quarters, and provided costs for 5 annual rounds of sampling. Excelsior indicated that this was appropriate "based on the low hydraulic gradients and slow travel times observed in the project area."

EXCELSIOR RESPONSE:

Please refer to the response to comment 16 for the revised post-closure monitoring plan. As noted in Section 7.1.6 of the revised BADCT demonstration for the wellfield (in the response to comment 16:

Geochemical modeling (Appendix J.1 and Section 7.1.5.1) has shown that AWQs will be achieved after rinsing. Post closure monitoring (of closure verification wells or CVWs) will be conducted as summarized in the Section 7.1.5.1. Because Excelsior intends to rinse until MCLs and AWQs are achieved within the wellfield, monitoring at the POCs will not be conducted. Rather, post-closure monitoring will be conducted the selected CVWs within the wellfield for 5 years..The samples will be collected annually, according to the methodology prescribed in the permit. Costs for post-closure monitoring are provided in the revised Appendix M.

Excelsior has proposed that when AWQs and MCLs are achieved for five (5) successive years, post closure monitoring can be terminated and the remaining wells (monitoring, hydraulic control, POC) can be abandoned.

If in any year AWQs or MCLs are not met in a particular area, appropriate HC wells can be turned back on and additional pumping, rinsing or resting of CVWs and/or adjacent RVWs can occur.

Volume III - Appendix O – Alert Level Calculations for LCRS

CRAI Comment

51. A.A.C. R18-9-A202(A)(5)(a) - *The application only includes Alert Level 1 volume for the LCRS system. Please provide calculations for the Alert Level 1 (AL1) and Alert Level 2 (AL2) for all the double-lined ponds. Also, Section 3.2 Results has two tables containing “Depth” and “Max Depth”. Please explain what these depths represent. The “Max Depth” used in the calculations to determine the “Proposed AL” does not appear to match the depth presented in the drawings in Appendix K. For example, the drawing for the Raffinate Pond indicates the maximum depth at the shallow end is approximately 19 feet and the maximum depth at the deep end is 23 feet. Please explain why 7 feet used in calculating the AL.*

ADEQ Evaluation

The response to RAI 51 is **not** adequate.

Excelsior provided a revised Appendix O. Excelsior indicated that the pond floors are designed to slope. For the purpose of calculation, they chose to use the maximum depth determined at the lowest pond elevation as opposed to the average liquid depth.

The Alert Level Calculations for Leak Collection and Removal Systems provided in Appendix O is not sealed by a licensed engineer. Please provide a revised Appendix O.

EXCELSIOR RESPONSE:

A revised Appendix O that is sealed by a licensed engineer is attached.

APPENDIX O

**ALERT LEVEL CALCULATIONS
FOR LEAK COLLECTION AND REMOVAL SYSTEMS**

**AQUIFER PROTECTION PERMIT APPLICATION
GUNNISON COPPER PROJECT
M3-PN160076**

Prepared for:

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Craig A. Hunt
EXPIRES: 12-31-18

1. INTRODUCTION

This attachment includes Alert Level (AL) calculations for the Leak Collection and Removal Systems (LCRS) installed in APP-permitted impoundments for the Gunnison Copper Project. Six APP-regulated impoundments (Raffinate Pond, PLS Pond, Recycled Water Pond, Evaporation Pond #1, and Solids Impoundments 1 and 2) will be constructed with LCRSs. Each of these facilities will consist of a double liner with a leak collection layer and sump between the liners as described in the BADCT demonstration section of the APP Application. The ALs are equivalent to potential leakage rates (PLRs) calculated based on the design parameters of each facility (depth of solution in the pond and area of the pond) and expected leakage for installed liners.

2. EQUATIONS

The PLRs for a liner can be determined using Bernoulli's equation for free flow through an opening. The equation is shown below

$$Q = C_B a \sqrt{2gh_w}$$

Where:

Q = Rate of liquid migration or PLR through a hole (cubic meters per second [m³/s])

C_B = Dimensionless coefficient related to the shape of the edges of the hole (sharp edges C_B = 0.6)

a = Hole area (square meters [m²])

g = Acceleration due to gravity (9.8 meters per second squared [m/s²])

h = Liquid depth on top of the liner (meters [m])

3. CALCULATIONS

3.1 Assumptions

Giroud (1992) states that a hole size of 1 cm² (d = 11.3 mm) be used to size leakage collection systems and a hole size of 10 mm² per acre (d = 3.57mm) be used in the performance analyses of geomembrane liners that have been installed using rigorous construction quality assurance (CQA) procedures. The estimate assumes the holes are due to seam defects that are not detected by the construction quality assurance program.

3.2 Pond Parameters

The pond parameters are tabulated below. Each of the Solids Impoundments contains two cells. An AL was calculated for each cell of the Solids Impoundments.

Facility	Depth (ft)	Depth (m)	Area of Pond (ac)
Raffinate Pond	20.3	6.2	2.25
PLS Pond	20.3	6.2	2.25
Recycled Water Pond	12.7	3.9	0.51
Evaporation Pond #1	38.3	11.7	5.77
Solids Cell 1A	34.7	10.55	7.32
Solids Cell 1B	34.7	10.55	7.32
Solids Cell 2A	34.7	10.55	7.32
Solids Cell 2B	34.7	10.55	7.32

3.3 Alert Level 1 (AL1) Calculations

As discussed in Section 2, a value of 0.6 was used for C_B and 9.8 m/s^2 was used for g . Assuming a 3.57 mm diameter hole, the hole area is 0.00001 m^2 . Using these variables, the PLR per defect was calculated as shown below.

Facility	Max Depth (ft)	Max Depth (m)	Area of Pond (ac)	PLR per Defect ($\text{m}^3/\text{s}/\text{defect}$)	PLR for Facility (m^3/s)	Proposed AL1 (gpd)
Raffinate Pond	23	7.0	2.25	7.03679E-05	0.000158	3,618
PLS Pond	23	7.0	2.25	7.03679E-05	0.000158	3,618
Recycled Water Pond	14	4.3	0.51	5.49003E-05	0.000028	639
Evaporation Pond #1	45	13.7	5.77	9.84277 E-05	0.000568	12,972
Solids Cell 1A	40	12.2	7.32	9.27985E-05	0.000680	15,513
Solids Cell 1B	40	12.2	7.32	9.27985E-05	0.000680	15,513
Solids Cell 2A	40	12.2	7.32	9.27985E-05	0.000680	15,513
Solids Cell 2B	40	12.2	7.32	9.27985E-05	0.000680	15,513

Giroud and Bonaparte (1989) assume one defect per acre. Therefore the PLR per defect (shown in cubic meters per second per defect) was multiplied by the area of the facility to arrive at the PLR for each facility. The AL is equal to the PLR for each facility (shown in cubic meters per second), however it was converted to gallons per day (gpd) for ease of use. The conversion from m^3/s to gpd is completed as follows:

$$\frac{1 \text{ m}^3}{\text{s}} \times \frac{60 \text{ s}}{1 \text{ min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{24 \text{ hr}}{1 \text{ d}} \times \frac{264.172 \text{ gal}}{1 \text{ m}^3} = 22,824,461 \times \frac{\text{m}^3}{\text{s}}$$

3.4 Alert Level 2 (AL2) Calculations

The AL2 value is a derived value. It is based on the design flow, but is lowered by the application of a safety factor. In other words the leak collection system should be designed to accommodate a leakage flow capacity that exceeds the AL2 value. Assuming an 11.3 mm diameter hole, the hole area is 0.0001 m². Dividing by a generally accepted safety factor of 1.5, the AL2 flow rates were calculated as shown below.

Facility	Max Depth (ft)	Max Depth (m)	Area of Pond (ac)	PLR per Defect (m ³ /s/defect)	PLR for Facility (m ³ /s)	Proposed AL2 (gpd)
Raffinate Pond	23	7.0	2.25	0.00046912	0.001057	24,117
PLS Pond	23	7.0	2.25	0.00046912	0.001057	24,117
Recycled Water Pond	14	4.3	0.51	0.00036600	0.000187	4,260
Evaporation Pond #1	45	13.7	5.77	0.00065618	0.003789	86,480
Solids Cell 1A	40	12.2	7.32	0.00061866	0.004531	103,417
Solids Cell 1B	40	12.2	7.32	0.00061866	0.004531	103,417
Solids Cell 2A	40	12.2	7.32	0.00061866	0.004531	103,417
Solids Cell 2B	40	12.2	7.32	0.00061866	0.004531	103,417

4. REFERENCES

Giroud, J.P., and Bonaparte, R., 1989, "Leakage through Liners Constructed with Geomembranes, Part I, Geomembrane Liners", *Geotextiles and Geomembranes*, Vol. 8, No. 1, 1989, pp. 27-67.

Giroud, J.P., Badu-Tweneboah, K., and Bonaparte, R., 1992, "Rate of Leakage through a Composite Liner due to Geomembrane Defects", *Geotextiles and Geomembranes*, Vol. 11, No. 1, 1992, pp. 1-28.

CRAI Comment

53. *Submit revised closure and post-closure cost estimates which comply with the requirements of A.A.C. R18-9-A201(B)(5), based on the respective comments presented in the hydrology and engineering sections above.*

ADEQ Evaluation

The response to RAI 53 is **not** adequate.

Excelsior indicated “Revised closure costs will be submitted by Excelsior, after review and approval by ADEQ and EPA of responses to comments 45 through 50.” Based on ADEQ comments to RAI 45 through 50, submittal of revised closure and post-closure costs may be required. Additionally, please note that ADEQ will require the revised closure/post-closure costs to be submitted irrespective of EPA’s approval.

EXCELSIOR RESPONSE:

A revised Appendix M is provided.

APPENDIX M

**Revised in response to Comments from ADEQ dated
June 17, 2016 and February 14, 2017**

Stage 1 Closure Costs

Gunnison Copper Project

Prepared for:

Excelsior Mining Arizona, Inc.

January 2016 (M3 Engineering)

Revised September 2016 (by M3 Engineering)

Revised April 11, 2017 (by Axelrod, Inc.)

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Attachment: Compact Disc with Excel Spreadsheets

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Table M-5: Power Cost for Hydraulic Control Well Pumping

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Table M-7: Wellfield Rinsing Credits by Year

Table M-8: Worksheet used to Calculate Rinsing Verification Unit Costs



This stamp is applicable to the original and first revision

Table M-9: Closure Costs - Pipeline Drain Pond

Table M-10: Post Closure Costs - Pipeline Drain Pond

Table M-11: Closure Costs –Evaporation Pond

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Attachment: Compact Disc with Excel Spreadsheets

Tables

Table M-1: Closure Cost Detail

Table M-2: Labor Hourly Costs

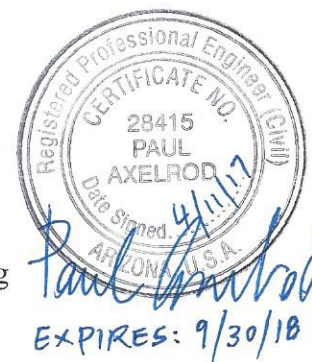
Table M-3: Power Cost for Fresh Water Supply Pumping for Rinsing

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This stamp is
applicable to the
April 2017 revisions

Table M-8: Wellfield Rinsing Credits by Year

Table M-9: Worksheet used to Calculate Rinsing Verification Unit Costs

Table M-10: Closure Costs - Pipeline Drain Pond

Table M-11: Post Closure Costs - Pipeline Drain Pond

Table M-12: Closure Costs –Evaporation Pond 1

Table M-13: Post Closure Costs - Evaporation Pond 1

Table M-14: Year-By-Year Well Abandonment Cost Summary

Table M-15: Cost for Five Years of Post-Closure Monitoring

Table M-16: Well Abandonment Cost Detail

Executive Summary

A closure strategy and cost estimate for the Stage 1 Gunnison ISR wellfield has been developed in accordance with ADEQ, ADWR, EPA UIC, and BADCT guidelines. The closure activities allowed for include ISR wellfield rinsing, pullback pumping, well abandonment, and closure of the Gunnison Evaporation Pond and Pipeline Drain Pond.

The most extensive activity will be the rinsing of the wellfield that will require flushing the leached formations with clean water, the extraction of the impacted rinse water, and evaporating it in the Gunnison Evaporation Pond #1. Pullback pumping has been allowed for to capture particles from the in-situ leaching that may have migrated from the mining area. A gradient into the mining area created by the pullback pumping will allow for the capture of the particles. Costs have been developed for general administration, wellfield labor and maintenance, power for wellfield pumps needed for rinsing, pullback pumping, mechanical evaporators, rinsing verification monitoring, and post-closure monitoring.

Well abandonment will be conducted according to ADWR guidelines by removing the wellhead piping and pumps followed by grouting the boreholes in accordance with EPA UIC requirements. Wells scheduled for abandonment include injection and recovery wells, hydraulic control wells, observation wells, intermediate monitor wells (IMWs), rinse verification wells, and Point-of-Compliance (POC) wells. Costs for abandonment were developed using third party contractor costs and include labor and supervision, pre-grouting activities, grouting, perforation (where applicable), casing removal to two feet below the surface, and debris removal.

Pond closure strategies for the Gunnison Evaporation Pond #1 and Pipeline Drain Pond required for Stage 1 production have been developed, including the removal of mechanical evaporators, various earthworks, dewatering, placement of geotextile for covering evaporation solids, rip-rap to protect surface drainages, and revegetation/reseeding of the pond surfaces after covering.

The closure cost liabilities by year are tabulated below for the ten years covering Stage 1. Credits have also been tabulated for the closure activities that will have been completed by a given year. From the closure liabilities and credits, the maximum liability occurs in Year 10.

The closure costs will be re-evaluated in Year 6. From the table, the difference in cost between Year 10 and Year 6 is approximately \$700,000 and can be used as a contingency for additional pullback pumping if required in Years 1 through 6.

Table: Summary of Closure Costs and Closure Credits by Year (\$Millions)

Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Rinsing	1.708	2.175	2.623	3.013	3.041	3.159	3.039	3.091	2.962	2.993
Well Abandonment	1.232	1.637	1.895	2.291	2.659	3.019	3.640	3.695	3.697	3.767
Pond Closure	0.821	0.821	0.821	0.821	0.821	0.821	0.821	0.821	0.821	0.821
Other**	0.254	0.257	0.261	0.262	0.262	0.264	0.262	0.262	0.262	0.262
Pullback Pumping	1.850	1.539	1.254	0.995	0.902	0.834	0.897	0.865	0.933	0.923
Contingency (10%)	0.587	0.643	0.685	0.738	0.769	0.810	0.866	0.873	0.867	0.877
Total (no credit)	6.452	7.072	7.539	8.120	8.454	8.907	9.526	9.608	9.542	9.644
Credit	0.000	0.000	0.000	0.000	-0.132	-0.085	-0.164	-0.123	-0.136	-0.120
Total with credit	6.452	7.072	7.539	8.120	8.321	8.822	9.362	9.485	9.407	9.524

Closure Plan for the ISR Wellfield

Closure of the ISR wellfield requires rinsing and neutralization of the portions of the formation that have been exposed to leach solution. The wells will be closed and abandoned in accordance with UIC regulations and Arizona Department of Water Resources (ADWR) guidance after rinsing has reduced all constituents to appropriate concentrations.

Metallurgical test results and geochemical modeling indicate that neutralization and constituent concentration reduction to appropriate levels can be accomplished by a three-step process (as described in Appendix J.1). First, the acidified leaching solution is replaced with clean water to dilute the concentration of leach solution in the formation to approximately 5 percent (Appendix J.2). Second, active circulation of solutions within the subject portion of the wellfield is suspended for approximately 200 days to neutralize the acid. Geochemical modeling based on mineralogy indicates that the leached formation will have sufficient acid neutralizing potential to raise the pH to near neutral. The third step is additional flushing with clean water to reduce regulated constituents to acceptable concentrations. The first rinsing step will require three pore volumes and the second rinse (third step) will require two pore volumes (Appendix J.1). AWQSS are expected to be met after the rest period; the two additional pore volumes are for extra confidence in the expected results.

Clean water for rinsing during Stage 1 production will be provided by water supply wells and unimpacted hydraulic control water. Water for rinsing Stage 2 and Stage 3 wells is anticipated to also include recycled water from a water treatment plant constructed in later stages. For Stage 1, rinse water will directly flow by gravity from the Fresh Water Tank on the Johnson Camp Mine property. In Stages 2 & 3, water for rinsing will be pumped from the Clean Water Pond. In both cases, water will be injected into the production wellfield. Extracted water during rinsing will be pumped to the Evaporation Pond for disposal by natural and mechanical evaporation. The “first flush”, which can be considered the first pore volume, from Step 1 rinsing is expected to contain sufficient copper grade for economical extraction in the SX-EW plant. After the copper concentration drops below the economic threshold, the remainder of rinsate extracted will be sent to the Evaporation Pond.

Rinsing is considered complete when the concentrations of all constituents are at or below AWQSS. Wells that are accepted as being sufficiently rinsed¹ will be abandoned in accordance with EPA and ADWR criteria. The wells will be grouted from bottom upward using a tremie pipe to eliminate its ability to act as a conduit for solution migration.

¹ With the exception of wells that will be used as Rinse Verification and Closure Verification wells. These will be left open for monitoring and will be abandoned later according to the closure strategy.

ISR Wellfield Closure Liability

When wells are added and put into production, they are assumed to accrue a liability for the complete three step rinsing, as described above. This liability includes all the components of rinsing, verification, and abandonment. This liability continues to grow until rinsing begins. As the rinsing and closure of wells progresses, the liability is reduced in the year that operations are completed in the form of rinsing credits and the removal of wells from the number that need to be abandoned for the subject year. For example, if 183 wells are present at the beginning of the year, 16 are closed (abandoned), and 14 are added, the year-end liability for well abandonment is 181.

The process of rinsing the production wellfield is expected to take approximately two years, since the time duration is dominated by the need to "rest" the wells in order to neutralize the solution. If there are 40 cells (five spot patterns) that need to be rinsed, the first 20 are rinsed for approximately 200 days to achieve three pore volumes of rinsing. The first 20 cells are put into "resting mode" while the second group of 20 cells is rinsed with three pore volumes. The second group is rested while the first group is rinsed with the final two pore volumes for approximately 130 days. After 70 more days of "resting," the second group of wells is rinsed for the final 130 days with an elapsed time of 730 days or 2 years. The volume of cumulative rinsing liability (in gallons) is divided by 576,000 gallons (400 gpm x 60 min x 24 hrs) to approximate the time (in days) for rinsing all of the wells. An additional 10% is added to the time to account for overlaps and inefficiencies in moving from one group of cells to the next.

Costs to complete the wellfield closure and abandonment process have been estimated for each year of Stage 1 operation. Closure of the spent portions of the wellfield is planned to take place throughout the life of the operation beginning in Year 5 when the first wells are anticipated to produce copper concentrations that fall below economic cutoff. These costs are based on evaluating the annual closure liability for each year of Stage 1 operation.

Pullback Pumping

Pullback pumping costs are included in the closure costs to allow for the capture of potential solution excursions from the active mining blocks. Model simulations were made to evaluate capture in years 1 and 5. Excelsior does not believe modeling closure scenarios after year 5 is necessary given that Excelsior will be reviewing the model performance as compared to actual operations as part of the planned review of closure cost bonding after year 6. Modeling at that time will incorporate updates based on operations and monitoring data.

The pullback pumping will draw down the water table and form a gradient into the mining area which will facilitate solution capture. The assumptions used for the pullback pumping are conservative because normal mine operations will create a sweep affect around the perimeter of a

mining block specifically to recover mining solutions. Also, no control strategies are simulated, such as local over-pumping to control detected excursions.

In the model simulations, particles initially migrate away from mining blocks but then the paths are reversed and particles are captured when recovery operations begin after a mining year. The modeling shows that all particles are captured within 3 years after recovery operations start, with most being captured within one year of recovery pumping. The only hydraulic control (HC) wells that need to be operated in the Year 1 and Year 5 scenarios are the two along the southern boundary of the wellfield.

The pullback pumping will be conducted in conjunction with rinsing of the wellfield which will take place over 3 years. Pullback pumping rates are limited by the available capacity of the mechanical evaporators. The capacity of the mechanical evaporators taking into account weather, efficiency etc. is estimated to be 490 gpm. The flow rate for pullback pumping is the difference between the evaporator capacity and the rinse and HC water. HC pumping is not counted for year 1 pullback pumping since it has been assumed it can be used as rinse water. Year 2 after cessation is the rinsing rest year, so the difference between the evaporative capacity and the HC pumping can be used for pullback pumping. The pullback pumping in years 1 and 3 of the rinsing cycle is estimated to also reduce the rinsate volumes by an equal amount since the pullback water will draw in fresh water and naturally rinse. The pullback volumes have been reduced by the rinsate volumes in years 1 and 3 of the pullback/rinsing cycle which is conservative since the rinsate pumping costs are higher than the pullback pumping costs.

The pullback volumes for years 6 through 10 are the same as for the Year 5 scenario because the overall pumping rate has been fixed at 490 gpm, not to exceed the capacity of the mechanical evaporators, and capture should be achieved by pumping close to this rate for cessation in years 6 through 10.

As for the previous closure cost estimate, the volume of hydraulic control water is based on 4 years of pumping. The volume of HC water has been updated to include the volume for the year of cessation plus the HC volumes for the three rinsing cycle years from the pullback model.

Costs for the pullback pumping have been estimated for each year of Stage 1. The additional labor and power costs for pullback pumping have been included with the closure costs.

Closure Cost Estimation for Bonding

The following sections provide details on the various cost categories shown in **Table M-1**, provided at the end of this document.

Work Plans and Mobilization

In the event that the operators of the project default on their obligations under the permit, it is assumed that the State would have the responsibility of completing closure and post-closure operations for purposes of calculating the closure bond. The State would likely hire a remediation contractor to conduct the necessary closure and post-closure operations, using subcontractors where necessary to perform such services as rinsing, pullback pumping, well abandonment, pump replacement, earth moving, and revegetation. It is also assumed that the contractor would have to prepare work plans, assemble a team and mobilize to the site to begin rinsing and closure operations. A lump sum estimate of \$75,000 has been allocated for the preparation of work plans. An additional \$20,000 has been allocated for mobilization and demobilization from the site.

Labor Costs

The operation of the wellfield and evaporators can be managed by a supervisor, two operators, and an electrician during the pullback/rinsing cycle. The duration of the rinsing operation is calculated in accordance with the rinsing liability remaining in the year that closure takes place. The total rinsing liability volume, calculated as presented above, is divided by the rinsing volume available in one day from 400 gpm of water supply (576,000 gallons per day) to estimate the duration (in days) of the rinsing operation. An additional 10% is added to the duration to reflect lag time in operations and inefficiencies in moving from block to block.

Labor costs to manage the pullback pumping have been included for years 1, 2 and 3 of the pullback/rinsing cycle. It is assumed that the staff managing the rinsing and evaporation will also manage the pullback pumping. The labor cost for rinsing and evaporation is based on the duration of the rinsing operation. The additional labor costs for pullback pumping include the staff for year 2, the resting year of the rinsing cycle, and for the balance of time in years 1 and 3 if only part of them were required for rinsing.

The assumption that the staff for the rinsing and evaporation will also cover the pullback pumping is based on the pumping rates for rinsing and HC wells in years 1 and 3 being less under the pullback scenarios than allowed for previously in the closure costs.

Hourly rates for the wellfield rinsing and pullback pumping staff are shown in Table M-2 and unit costs are shown in Table M-1 on Lines 59-63.

Table M-2: Labor Hourly Costs

Position	Quantity	Hourly Rate
Project Manager	1	\$125
Rinsing Supervisor	1	\$72
Wellfield Operator	2	\$56
Wellfield Electrician	1	\$44
Site Security	1	\$30
Overhead	10%	

Hourly rates were obtained by using R.S. Means conversions of local, published salaries for specific positions. Labor costs were developed by taking the rinsing duration in days and dividing them by 7 to determine number of weeks of rinsing duration. The project manager was assigned 10 hours per week while the field personnel were assigned 40 hours per week. Site security was assigned 60 hours per week to monitor the wellfield at night. A wellfield operator will also be on call when site security is monitoring the wellfield. An overhead charge of 10% was applied to all labor rates to cover such things as vehicle use and administrative and field expenses.

Pump Replacement Costs

Before rinsing can begin as the first step in closure operations, submersible pumps in the recovery wells need to be changed for similar pumps with a smaller discharge rate. Rinsing operations are limited by the supply of fresh water available at the Johnson Camp Mine (approximately 400 gpm), so it is impractical to rinse the wellfield at production-level injection rates. A subcontractor with well maintenance experience will be used to change the pumps.

During production, the recovery wells will typically be sized to pump approximately 80 gpm. During rinsing, the recovery pumping rates for rinsate will be typically 25% of that rate, or 20 gpm, requiring a change in the pumps to operate efficiently. Costs for pump replacement and well maintenance have been estimated on a contract basis using a quote from Verdad, Inc. in Tucson. The cost for a replacement pump for 20 gpm recovery is estimated at \$2,990. Labor, rig costs, and per diem are estimated at 4 hours per well for rig and labor costs, and ½ day of per diem per well. A single mobilization charge of \$1,500 is estimated for pump replacement. It was assumed that a new submersible well pump would be capable of recovering rinsate for the estimated 330 days of pumping required without significant maintenance costs.

The recovery well pumps are suitable for the pullback pumping. The pumps will be raised in the wells as required for an adequate water column for pumping and drawdown. Costs for pump raising and well maintenance are covered by changing out the recovery pumps for rinsing.

Quarterly Reporting

As mentioned above, in the event that the operators of the project default on their obligations under the permit, it is assumed that the State would have the responsibility of completing closure and post-closure operations for purposes of calculating the closure bond. The State's remediation contractor will prepare quarterly reports. In any given year, the number of reports that it will take to complete rinsing will vary, depending on how many cells must be rinsed. For example, in Year 4, the duration of rinsing needed for existing wells is 676 days (Line 5 of Table M-1) so there will be 8 quarterly reports prepared (Line 23).

Power Costs

The primary cost of rinsing and pullback pumping is power. Power costs are based on the unit rates (\$0.08/kWh) from Sulphur Springs Valley Electric Co-operative to the Johnson Camp Mine during recent operation before the mine went into care and maintenance. Unit power costs (\$/Mgal) are discussed below for the following:

- Water Supply Pumping for Rinsing
- Rinse Recovery Pumping
- Hydraulic Control Pumping
- Pullback Pumping
- Mechanical Evaporation

Water supply costs for rinsing are based on the existing wells at the Johnson Camp Mine and the estimated power cost to pump 400 gallons per minute (gpm) divided by the flow rate requirement to accomplish the rinsing. Water supply is provided by two 60 hp pumps capable of producing 400 gpm. The cost per gallon of water supply for rinsing is \$0.0002685, or \$268.45 per million gallons (/Mgal) as shown in Table M-3.

Table M-3: Power Cost for Fresh Water Supply Pumping for Rinsing

Description	Units	Quantity
Water Supply output	gpm	400
Conversion	gph	24,000
Water Supply Pump motors	hp	120
Conversion	kW/hp	0.746
Power Factor	%	90
Power usage	kW	80.5
Cost per kW-hr	\$	0.080
Pumping Cost per hour	\$	6.44
Water Supply Power Cost	\$/gal	0.0002685
Water Supply Power Cost	\$/Mgal	\$268.45

The rinse recovery pumping liability assumes a 5 hp motor capable of pumping 15 gpm per well against a total dynamic head of over 600 feet with a power cost of \$0.08 per kilowatt-hour (kW-hr) to extract rinse water. The cost per gallon of rinse recovery pumping is \$0.00029828, or \$298.28/Mgal as shown in Table M-4

Table M-4: Power Cost for Rinse Recovery Well Pumping

Description	Units	Quantity
Rinse Recovery Pumping	gpm	15
Conversion	gph	900
Recovery Pump motors	hp	5
Conversion	kW/hp	0.746
Power Factor	%	90
Power usage	kW	3.4
Cost per kW-hr	\$	0.080
Pumping Cost per hour	\$	0.27
Rinse Recovery Pumping Cost	\$/gal	0.0002983
Rinse Recovery Pumping Cost	\$/Mgal	\$298.28

Hydraulic control wells are outfitted with 5 HP pumps. These pumps must be utilized throughout the rinsing process to ensure that hydraulic control is maintained to prevent excursions of impacted rinse solutions until the formations are adequately rinsed. Table M-5 summarizes the power consumption and cost of power for hydraulic control wells during closure.

Table M-5: Power Cost for Hydraulic Control Well Pumping

Description	Units	Quantity
Hydraulic Control Pumping	gpm	15
Conversion	gph	900
Recovery Pump motors	hp	5
Conversion	kW/hp	0.746
Power Factor	%	90
Power usage	kW	3.4
Cost per kW-hr	\$	0.080
Pumping Cost per hour	\$	0.27
Hydraulic Control Pumping Cost	\$/gal	0.0002983
Hydraulic Control Pumping Cost	\$/Mgal	\$298.28

The pullback pumping liability assumes a 16 hp motor capable of pumping 200 gpm per well against a total dynamic head of over 250 feet with a power cost of \$0.08 per kilowatt-hour (kW-hr) to extract pullback water. The cost per gallon of pullback pumping is \$0.0007159, or \$71.59/Mgal as shown in Table M-6.

Table M-6: Power Cost for Pullback Pumping

Description	Units	Quantity
Pullback Pumping	Gpm	200
Conversion	Gph	12000
Pullback Pump motors	Hp	16
Conversion	kW/hp	0.746
Power Factor	%	90
Power usage	kW	10.7
Cost per kW-hr	\$	0.080
Pumping Cost per hour	\$	0.86
Pullback Pumping Cost	\$/gal	0.0000716
Pullback Pumping Cost	\$/Mgal	\$71.59

Power costs for mechanical evaporation of the rinsate is based on vendor information using climatic data for the Johnson Camp mine. The annual average evaporation required is 37.6 million gallons. The evaporator model that has been selected for purposes of this estimate is the Mega Polecat model from SMI Evaporative Systems. One operating evaporator and one standby evaporator are needed in Years 1 and 2. The number of evaporators reaches a maximum seven operating and one standby in Year 7. However, in full-scale rinsing during closure the available rinse water flow heading to evaporation will be 490 gpm, requiring 11 evaporators total. The capital cost for adding 9 evaporators (11 total) at \$91,000 per evaporator (with controls, based on a quote from SMI Evaporative Solutions) is held constant throughout the closure cost estimate to provide for the additional units required during closure.

The capacity of one evaporator is 130 gpm with an average evaporation efficiency calculated from manufacturer's data of 55% for an evaporation rate of 71.5 gpm, or 4,290 gallons per hour. The fan motor and pump to supply water to the unit total 90 hp. The unit rate for evaporation is \$0.001129 per gallon, or \$1,126.83 per million gallons as shown in Table M-7.

Table M-7: Power Cost for Mechanical Evaporation

Description	Units	Quantity
Evaporation Rate	gpm	71.5
Conversion	gph	4,290
Fan Pump	hp	60
Feed Pump	hp	30
Conversion	kW/hp	0.746
Power Factor	%	90
Power usage (fan+pump)	kW	60.4
Cost per kW-hr	\$	0.080
Evaporator Power Cost per hour	\$/hr	4.83
Evaporation Power Cost	\$/gal	0.0011268
Evaporation Power Cost	\$/Mgal	\$1,126.83

Wellfield Rinsing Credits

The process of closing production wells is scheduled to begin in Year 5 of production. The first step in closure of production wells is early rinsing in which the leaching solution is replaced with clean water to dilute the pore water in the formation approximately 95 percent. Geochemical studies (Appendix J.1) indicate that this will require injection of approximately three pore volumes of clean water. When this has been accomplished, the closure liability is reduced by the cost of that rinsing and is shown as a credit (Line 111 of Table M-1 and Table M-8). The early rinsing credit is calculated as three-fifths of the rinsing liability, since it involves three of the five pore volumes necessary to complete the rinsing.

The second step of rinsing involves shutting down the wellfield for approximately 200 days. Rinse water injection and rinsate recovery is stopped to allow the remaining solution to be neutralized by the formation. The natural acid neutralizing potential of the formation has been shown by metallurgical test work to bring the rinse water resting in the formation to near neutral pH in approximately 200 days.

Additional rinsing is conducted in step three to flush out constituents remaining in the formation after neutralization. Geochemical modeling indicates that an additional two pore volumes of

rinse water needs to be injected and recovered to reduce all constituents to acceptable concentrations. In the rinsing schedule this 200 days is approximated by one year. The rinsing credit for this late rinsing is the remaining two-fifths of the water supply, rinsate extraction pumping, rinsate pumping, and evaporation liability.

Table M-8: Wellfield Rinsing Credits by Year

Category	Rate	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Early Rinse cells		5-Spot					14	9	8	7	9	8
Pore volume @ 3% porosity per cell	1.863	Mgal					26.077	16.764	14.901	13.039	16.764	14.901
Early Rinse volume	3 pore volumes	Mgal					78.231	50.292	44.704	39.116	50.292	44.704
Water Supply Power Credits	\$268	\$/Mgal					\$21,001	\$13,501	\$12,001	\$10,501	\$13,501	\$12,001
Rinse Recovery Pumping Power Credits	\$298	\$/Mgal					\$23,335	\$15,001	\$13,334	\$11,667	\$15,001	\$13,334
Early Rinsate Pumping Credits	\$0	\$/Mgal					\$0	\$0	\$0	\$0	\$0	\$0
Evaporation Power Credits	\$1,127	\$/Mgal					\$88,153	\$56,670	\$50,373	\$44,076	\$56,670	\$50,373
Yearly Early Rinse Credits							\$132,489	\$85,172	\$75,708	\$66,245	\$85,172	\$75,708
Late Rinse Blocks		block							14	9	8	7
Pore volume @ 3% porosity per cell	1.863	Mgal							26.077	16.764	14.901	13.039
Late Rinse volume	2 pore volumes	Mgal							52.154	33.528	29.802	26.077
Water Supply Power Credits	\$268	\$/Mgal							\$14,001	\$9,001	\$8,001	\$7,000
Rinse Recovery Pumping Power Credits	\$298	\$/Mgal							\$15,557	\$10,001	\$8,889	\$7,778
Late Rinsate Pumping Credits	\$0	\$/Mgal							\$0	\$0	\$0	\$0
Evaporation Power Credits	\$1,127	\$/Mgal							\$58,769	\$37,780	\$33,582	\$29,384
Yearly Late Rinse Credits							\$0	\$0	\$88,326	\$56,781	\$50,472	\$44,163
Total Yearly Wellfield Rinsing Credits							\$132,489	\$85,172	\$164,034	\$123,026	\$135,644	\$119,871

Rinsing Verification Sampling

Rinsing verification consists of groundwater monitoring of injection/recovery wells after the last step of rinsing. The cost was calculated for each year of Stage 1 (Years 1-10) based on the number of injection and recovery wells in existence during that year (Table M-9). The following assumptions were made:

- Labor costs are based on Clear Creek Associates' Staff 1 billing rate, which is the appropriate staffing level for this task.
- Ten percent (10%) of injection/recovery wells that were rinsed will be sampled after early and late rinsing stages.
- Current pricing from Turner Laboratories in Tucson, AZ was used to calculate analytical laboratory costs.
- No purging is required as the wells will be sampled at the end of the last rinsing step so they will already be purged.
- Assumed 1.5 hours of collection time per sample.

Table M-9: Worksheet used to Calculate Rinsing Verification Unit Costs

Table M-9 Verification Sampling Cost Estimate													
				YEAR									
				Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Description	Qty	Rate	Unit	24	4	5	6	6	6	6	6	6	6
Sample collection (1 hours per sample--no purging required)	1.5	\$95.00	hr	\$ 3,420	\$ 570	\$ 713	\$ 855	\$ 855	\$ 855	\$ 855	\$ 855	\$ 855	\$ 855
Field Parameters Meter (Clear Creek Rate)	2	\$25.00	day	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50
Misc. field costs per well (2)	1	\$25.00	each	\$ 600	\$ 100	\$ 125	\$ 150	\$ 150	\$ 150	\$ 150	\$ 150	\$ 150	\$ 150
Mileage (from Tucson) based on 2 trips per year	280	\$0.55	each	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154
Field Truck (Clear Creek Rate)	2	\$95.00	daily	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190
Generator Rental (trailer mounted, from Sunstate Rentals)(3)	1	\$713.00	week	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713
Laboratory Costs (TURNER)(1)													
Dissolved Metals ICP (Sb, As, Ba, Be, Cd, Cr, Pb, Se, Th, Ni)	1	\$80.00	sample	\$ 1,920	\$ 320	\$ 400	\$ 480	\$ 480	\$ 480	\$ 480	\$ 480	\$ 480	\$ 480
Mercury dissolved	1	\$41.00	sample	\$ 984	\$ 164	\$ 205	\$ 246	\$ 246	\$ 246	\$ 246	\$ 246	\$ 246	\$ 246
Fluoride	1	\$20.00	sample	\$ 480	\$ 80	\$ 100	\$ 120	\$ 120	\$ 120	\$ 120	\$ 120	\$ 120	\$ 120
VOCs	1	\$150.00	sample	\$ 3,600	\$ 600	\$ 750	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900
TDS	1	\$21.00	sample	\$ 504	\$ 84	\$ 105	\$ 126	\$ 126	\$ 126	\$ 126	\$ 126	\$ 126	\$ 126
pH--field	1	\$0.00	sample	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
nitrate+nitrite	1	\$30.00	sample	\$ 720	\$ 120	\$ 150	\$ 180	\$ 180	\$ 180	\$ 180	\$ 180	\$ 180	\$ 180
dissolved U	1	\$150.00	sample	\$ 3,600	\$ 600	\$ 750	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900
Ra226 + Ra 228	1	\$195.00	sample	\$ 4,680	\$ 780	\$ 975	\$ 1,170	\$ 1,170	\$ 1,170	\$ 1,170	\$ 1,170	\$ 1,170	\$ 1,170
gross alpha	1	\$85.00	sample	\$ 2,040	\$ 340	\$ 425	\$ 510	\$ 510	\$ 510	\$ 510	\$ 510	\$ 510	\$ 510
Data Management, Reporting per sample	2	\$95.00	hr	\$ 4,560	\$ 760	\$ 950	\$ 1,140	\$ 1,140	\$ 1,140	\$ 1,140	\$ 1,140	\$ 1,140	\$ 1,140
Annual Cost				\$28,215	\$ 5,625	\$ 6,755	\$ 7,884	\$ 7,884	\$ 7,884	\$ 7,884	\$ 7,884	\$ 7,884	\$ 7,884
Unit Cost per Sample				\$ 1,176	\$ 1,406	\$ 1,351	\$ 1,314	\$ 1,314	\$ 1,314	\$ 1,314	\$ 1,314	\$ 1,314	\$ 1,314
Notes:													
(1) Unit Costs from Turner Laboratories in Tucson, AZ													
(2) Ice, disposables, fuel for generator.													
(3) weekly unit rate is marked up by 15%. Rate from SunState													
Quantity of RWV wells is 24 for mine block 1 (all recovery wells). In subsequent years, # of RWV wells is 10% (rounded up) of the wells in the wellfield for that mine year block. RWV wells will be recovery wells.													

The number of wells specified in Table M-9 for rinsing verification are based on the number of recovery wells in production in any given year, as shown on Table M-16 in the second row from the top. In year 1 there will be 24 recovery wells. Excelsior has agreed to conduct rinsing verification in all of the Year 1 recovery wells. Thereafter, 10% of the rinse wells will be sampled for rinsing verification. The quantities in Table M-9 were rounded up. (Table M-9 above is a revision of Table M-8 from the previous revision of this document. The quantities do not match for two reasons: (1) because the previous version included 2 rounds of verification samples and (2) the number of wells was in the early version was based on 10% of the total recovery wells (in production and in rinsing) based on the September 1 response to comment 42. This methodology was incorrect because it counted recovery wells twice. The proper way to quantify the number of wells for verification sampling is by using the number of wells in production each year.)

The annual costs were divided by the number of samples per year to arrive at an annual unit cost (Table M-9). The lowest unit cost is in Year 1 (\$1,176 per sample in Year 1) because all of the recovery wells will be sampled while the highest was Year 2 (\$1,406 per sample). A unit cost of \$1,350 was used each year to calculate the closure costs for each year, as shown on Line 87 of Table M-1.

Evaporation Pond 1 and Pipeline Drain Pond Closure Costs

The closure of the Evaporation and Pipeline Drain Ponds will consist of items to achieve a vegetated soil cover over the pond footprint at the original ground level. Quantities used for the closure costs are based on the drawings and unit costs from contractor pricing for similar projects.

Pipeline Drain Pond

Initially, accumulated sediment will be removed from the pond floor followed by inspection of the liner for holes, testing of the soil underlying the holes and removal of any contaminated material. The liner will then be folded in and buried by the backfill material. After the pond has been backfilled to match the adjacent natural ground, the fill surface will be graded to drain and then hydro seeded to establish vegetation. Although the area is relatively flat, inspection and repair of eroded areas has been allowed for in the post closure costs. Table M-10 provides closure costs for the Pipeline Drain Pond and Table M-11 provides post closure costs.

Table M-10: Closure Costs - Pipeline Drain Pond

Construction Item	Unit	Quantity	Unit Cost \$	Cost \$
Mob/demob	ls	1	5,000.00	\$5,000.00
Earthworks				
- Clear and grub soil stockpile	ac	1	2000.0	\$2,000.00
- Load & haul pond sediment ¹	cy	250	15.0	\$3,750.00
- Load & haul contaminated soil ⁵	cy	100.0	15.0	\$1,500.00
- Backfill pond from stockpile for cover ²	cy	2,000	5.0	\$10,000.00
- Grade surface to drain	ac	0.5	3000.0	\$1,500.00
Testing				
- Soil sampling and analysis ⁴	ea	2.0	1600.0	\$3,200.00
Vegetation				
- Seed and mulch ³	ac	1	2000	\$1,000.00
Subtotal				\$26,950.00
Legal fees and regulatory oversight - 10%				\$2,695.00
Contingency - 25%				\$6,737.50
TOTAL				\$36,382.50

Pond Closure Plan Assumptions

1. Assumed sediment deposit 1 ft thick x 80% of outer impoundment dimensions.
2. Backfill depth = total depth of impoundment, required to establish grade.
3. Allowed 25% bigger than outer impoundment dimensions.
4. Sample and analysis rate 5/acre
5. Assumed amount from below pond

Table M-11: Post Closure Costs - Pipeline Drain Pond

Component	Unit	Unit Cost	Each	Each/yr	\$/year	Years	Cost \$
Direct Operating and Maintenance							
Inspection	hr	100	6	1	600	5	\$3,000
Erosion Repair	ls	700	1	1	700	5	\$3,500
Sub-total							\$6,500
Indirect Operating and Maintenance							
Administration (5% of direct)		325	1	1	325	5	\$1,625
Misc. fees (5% of direct)		325	1	1	325	5	\$1,625
Reserve (10% of direct)		650	1	1	650	5	\$3,250
Sub-total							\$4,875
TOTAL POND POST CLOSURE COSTS							\$11,375

Assumptions:

- 1) Inspection of surface required annually
- 2) Minor erosion repair required annually
- 3) Mine Post Closure Period: 5 Years

Evaporation Pond 1:

The costs include dewatering to obtain a working surface for placement of the soil cover. Dewatering allowed for consists of pumping free water to mechanical evaporators for a period of 3 months. Geotextile fabric will be used to bridge soft pond sediments and protect the liner during placement of the cover material. The costs allow for the cover to be placed slowly so that the underlying sediments can consolidate and gain strength for support. A cover thickness of 4

feet allows for settlement as the sediments consolidate. The cover surface will be graded to drain and then hydro seeded to establish vegetation. Post closure costs include inspection and repair of eroded areas. Table M-12 provides closure costs for the Evaporation Pond and Table M-13 provides post-closure costs.

Table M-12: Closure Costs –Evaporation Pond 1

Construction Item	Unit	Quantity	Unit Cost \$	Cost \$
Mob/demob	ls	1	20,000.00	\$20,000.00
Earthworks				
- Clear and grub soil stockpile	ac	6	2000.0	\$12,000.00
- Place fill from stockpile in pond for cover	cy	45,000	5.0	\$225,000.00
- Grade surface to drain	ac	14	3000.0	\$42,000.00
- Excavate ditches for erosion control	cy	2,000	4.0	\$8,000.00
Dewatering				
- Pump and pipes	ls	1	50000	\$50,000.00
- Evaporation costs (labor and power) for 3 months	ls	1	100000	\$100,000.00
Geosynthetics				
- Cut liner and fold in	lf	2,200	5	\$11,000.00
- 8 oz geotextile	sf	250,000	0.25	\$62,500.00
Riprap				
- Haul and place riprap in high flow areas	cy	1,000	25	\$25,000.00
Vegetation				
- Seed and mulch	ac	15	2000	\$30,000.00
Sub-total				\$555,500.00
Legal fees and regulatory oversight - 10%				\$55,550.00
Contingency - 25%				\$138,875.00
TOTAL				\$749,925.00

Pond Closure Plan

Closure for the Evaporation Pond will require placement of a soil cover.

- dewater by pumping free water from pool and sediment and evaporating
- place geotextile on the pond surface ahead of fill cover
- place soil cover (4 ft thick) at a slow rate onto geotextile/pond surface
- grade surface to drain and install ditches. Cover will be hydro-seeded

Table M-13: Post Closure Costs - Evaporation Pond 1

Component	Unit	Unit Cost	Each	Each/yr	\$/year	Years	Cost \$
Direct Operating and Maintenance							
Inspection ¹	hours	\$100	6	2	1,200	5	\$6,000
Erosion Repair ²	lump	\$1,500	1	1	1,500	5	\$7,500
Sub-total							\$13,500
Indirect Operating and Maintenance							
Administration (5% of direct)		\$675	1	1	675	5	\$3,375
Misc. fees (5% of direct)		\$675	1	1	675	5	\$3,375
Reserve (10% of direct)		\$1,350	1	1	1,350	5	\$6,750
Sub-total							\$10,125
TOTAL POND POST CLOSURE COSTS							\$23,625

Assumptions:

- 1) Semi-annual inspection of soil cover
- 2) Annual erosion repair
- 3) Mine Post Closure Period: 5 Years

Well Abandonment Costs

Clear Creek obtained unit costs from three licensed drilling companies in Arizona to compile well abandonment costs. Unit costs (i.e. cost per well to abandon) were calculated for the different types of wells: injection/recovery, hydraulic control, point of compliance, observation, and intermediate monitoring wells. Unit costs for abandonment of each well type are based on the well depth and diameter (volume of grout needed), and whether or not perforation will be required. Injection and recovery wells and hydraulic control wells will be open hole completion so the abandonment costs are relatively low. Observation wells, Point of compliance wells and the existing monitor wells (IMW's) which have screen and annular materials will be more expensive to abandon because they will require perforation. The average depth of wells in this portion of the mineralization is expected to be approximately 1,435 feet below land surface, so a depth of 1450 feet was used to calculate the well abandonment costs using third party unit costs provided by Yellow Jacket Drilling, a licensed well driller in Arizona.

Table M-14 below provides a summary of year-by-year abandonment costs for all wells in existence during each year of Stage 1 operations. Table M-16 (provided at the end of this text) provides detailed closure costs for each well type for each year.

Table M-14: Year-By-Year Well Abandonment Cost Summary

	Wellfield		HC Wells		Obs Wells		POC Wells		IMWs		RVWs		
Year	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	TOTAL
Y1	38	\$ 648,660	3	\$ 30,900	2	\$ 83,240	3	\$ 140,960	31	\$ 328,600	0	\$ -	\$ 1,232,360
Y2	58	\$ 970,660	5	\$ 51,500	4	\$ 166,480	3	\$ 140,960	29	\$ 307,400	0	\$ -	\$ 1,637,000
Y3	78	\$ 1,249,760	5	\$ 51,500	4	\$ 166,480	3	\$ 140,960	27	\$ 286,200	0	\$ -	\$ 1,894,900
Y4	95	\$ 1,562,600	6	\$ 61,800	6	\$ 249,720	3	\$ 140,960	26	\$ 275,600	0	\$ -	\$ 2,290,680
Y5	116	\$ 1,899,920	9	\$ 92,700	6	\$ 249,720	3	\$ 140,960	26	\$ 275,600	0	\$ -	\$ 2,658,900
Y6	132	\$ 2,156,240	11	\$ 113,300	8	\$ 332,960	3	\$ 140,960	26	\$ 275,600	0	\$ -	\$ 3,019,060
Y7	150	\$ 2,445,200	19	\$ 195,700	14	\$ 582,680	3	\$ 140,960	26	\$ 275,600	0	\$ -	\$ 3,640,140
Y8	150	\$ 2,442,200	19	\$ 195,700	14	\$ 582,680	3	\$ 140,960	25	\$ 265,000	4	\$ 68,000	\$ 3,694,540
Y9	148	\$ 2,410,160	19	\$ 195,700	14	\$ 582,680	3	\$ 140,960	25	\$ 265,000	6	\$ 102,000	\$ 3,696,500
Y10	152	\$ 2,468,240	19	\$ 195,700	14	\$ 582,680	3	\$ 140,960	23	\$ 243,800	8	\$ 136,000	\$ 3,767,380

Abandonment costs are provided for all existing wells for each year in Stage 1 (Years 1-10), including injection/recovery wells, observation wells, hydraulic control wells, POC wells, and the intermediate monitoring wells and rinse verification wells. The costs are not cumulative. Rather, we have calculated the abandonment costs for all of the wells that exist in any given year.

Assumptions used in calculating abandonment costs are provided at the bottom of the spreadsheet and are linked to the appropriate line items. Some of the key assumptions are:

1. Average total depth of wells is 1450 feet.

2. Average of 1150 feet of grout will be used to abandon each well to meet ADWR requirements for the grouted interval.
3. Injection/recovery wells will be open hole completion with a 7-inch diameter borehole.
4. Hydraulic control wells will be open hole completion with a 5-inch diameter borehole.
5. POC wells and observation wells will be constructed with screen and annular materials. Some of the existing NSH wells are constructed with screen and annular materials. Perforation costs are included for these wells.
6. Two mobilizations are included: one for the POC wells and another for all of the other wells.
7. Consultant labor rates are based on Clear Creek Associates' billing rates, which are consistent with the industry standard in Arizona.

The highest year for well abandonment in Stage 1 is Year 10, with a total cost of approximately 3.77 million.

Post-Closure Monitoring

Excelsior proposes a post-closure monitoring period, comprised of 5 years of annual monitoring at three POC wells. Post closure monitoring will also be conducted within the wellfield at Rinse Verification Wells (RVWs). The wellfield will be considered closed when five consecutive annual rounds of monitoring at the RVWs and the POCs meet AWQs and MCLs. While this monitoring is scheduled to take place over 5 years at the end of mining, the total cost is included for Years 1 to 10 in the event of premature cessation of operations. Costs for 5 years of post-closure monitoring are estimated to be \$154,230 as shown in Table M-15 below:

Table M-15: Cost for Five Years of Post-Closure Monitoring

	Quantity	Rate	Unit	markup %	Total	NOTE
Sample collection (8 hours per sample, 90 samples)	440	\$95.00	hr	0	\$41,800.00	(2)(3)
Field Parameters Meter	55	\$25.00	day		\$1,375.00	
Misc. field costs--5 events	5	\$300.00	lumpsum		\$1,500.00	(5)
Mileage (from Tucson) (90 days at 140 miles per day)	770	\$0.55	mile		\$423.50	(8)
Field Truck	55	\$95.00	daily		\$5,225.00	
Generator Rental (trailer mounted, from Sunstate Rentals)	10	\$713.00	week	15	\$8,199.50	(7)
Laboratory Costs						
Dissolved Metals ICP (Sb, As, Ba, Be, Cd, Cr, Pb, Se, Th, Ni)	65	\$80.00	sample	15	\$5,980.00	(1) (4)
Mercury dissolved	65	\$41.00	sample	15	\$3,064.75	(1) (4)
Fluoride	65	\$20.00	sample	15	\$1,495.00	(1) (4)
VOCs	65	\$150.00	sample	15	\$11,212.50	(1) (4)
TDS	65	\$21.00	sample	15	\$1,569.75	(1) (4)
pH --field	65	\$0.00	sample	0	\$0.00	(1) (4)
nitrate+nitrite	65	\$30.00	sample	15	\$2,242.50	(1) (4)
dissolved U	65	\$150.00	sample	15	\$11,212.50	(1) (4)
Ra226 + Ra 228	65	\$195.00	sample	15	\$14,576.25	(1) (4)
gross alpha	65	\$85.00	sample	15	\$6,353.75	(1) (4)
Data Management, Reporting, 5 annual reports	400	\$95.00	hr		\$38,000.00	
POC well plugging and abandonment						(6)
Oversight for well plugging and abandonment (5 POC wells)						(6)
Post-Closure Costs Total					\$154,230.00	
NOTES:				Yearly average	\$30,846.00	
This is for 5 years post closure monitoring starting at end of Stage 1 (Year 10)						
Assumptions						
(1) Total of 65 samples will be collected. ((3 POC wells+ 8 Closure Verification Wells) x (5 annual events) + (10 Duplicates))= 65 samples						
(2) 55 samples x 8 hours/sample = 440 hours						
(3) Duplicates not included in sampling time.						
(4) Unit Costs from Turner Laboratories in Tucson, AZ						
(5) Ice, disposables, fuel for generator.						
(6) Included in well abandonment spreadsheet						
(7) weekly unit rate is marked up by 15%. Rate from SunState						

Cumulative Closure Liability

The final row in Table M-1 (Line 112) shows the cumulative wellfield liability with deductions for closure expenses projected to have been accrued to that point on a year-by-year basis. The closure liability for Stage 1 production peaks in Year 10 at \$9.52 million. Without taking credit for scheduled closure items, the maximum closure liability is \$9.64 million, also occurring in Year 10.

TABLE M-1
CLOSURE COST DETAIL

LINE	Closure Costs	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
2	Mining Block Area	ft ²	140,000	90,000	80,000	70,000	90,000	80,000	80,000	90,000	60,000	80,000
3	Rinsing Volume (5 pore volumes)	Mgal	130.4	83.8	74.5	65.2	83.8	74.5	74.5	83.8	55.9	74.5
4	Cumulative Rinsing Volume	Mgal	130.4	214.2	288.7	353.9	359.5	383.7	361.4	372.5	348.3	352.0
5	Duration of Rinsing @ 400 gpm	days	249	409	551	676	687	733	690	711	665	672
6	Pullback Pumping Volume	Mgal	513	448	384	319	255	255	255	255	255	255
7			Quantities									
8	Prepare Work Plans	lump sum	1	1	1	1	1	1	1	1	1	1
9	Mobilization	lump sum	1	1	1	1	1	1	1	1	1	1
10	Labor											
11	Project Manager	hour	356	584	788	966	981	1,047	986	1,016	950	960
12	Wellfield Supervisor	hour	1,423	2,338	3,151	3,862	3,923	4,187	3,943	4,065	3,801	3,842
13	Wellfield Operators (2)	hour	2,846	4,675	6,301	7,724	7,846	8,375	7,887	8,131	7,602	7,683
14	Wellfield Electrician	hour	1,423	2,338	3,151	3,862	3,923	4,187	3,943	4,065	3,801	3,842
15	Site Security	hour	2,134	3,506	4,726	5,793	5,885	6,281	5,915	6,098	5,702	5,763
16												
17	Changing Pumps											
18	Recovery Wells		24	35	47	57	56	53	53	51	51	54
19	Mobilization	lump sum	1	2	2	2	2	2	2	2	2	2
20	Service Rig and Crew (2)	hour	96	140	188	228	224	212	212	204	204	216
21	Per diem	day	12	17.5	23.5	28.5	28	26.5	26.5	25.5	25.5	27
22												
23	Quarterly Reporting	quarter	3	5	7	8	8	9	8	8	8	8
24												
25	Volumes for Power Costs											
26	Water Supply	Mgal	130	214	289	354	359	384	361	373	348	352
27	Rinse Recovery Pumping	Mgal	130	214	289	354	359	384	361	373	348	352
28	Early Rinsate Pumping	Mgal	78	129	173	212	216	230	217	224	209	211
29	Late Rinsate Pumping	Mgal	52	86	115	142	144	153	145	149	139	141
30	Pullback Pumping	Mgal	513	448	384	319	255	255	255	255	255	255
31	Evaporation Volume Rinsate	Mgal	130	214	289	354	359	384	361	373	348	352
32	Evaporation Volume Pullback	Mgal	513	448	384	319	255	255	255	255	255	255
33	Hydraulic Control Pumping (4 yrs)	Mgal	50	56	61	67	73	73	73	73	73	73
34												
35	Rinsing Verification Sampling	sample	24	4	5	6	6	6	6	6	6	6
36												
37	Pond Closure											
38	Evaporation Pond Closure	each	1	1	1	1	1	1	1	1	1	1
39	Evaporation Pond Post Closure	each	1	1	1	1	1	1	1	1	1	1
40	Pipeline Drain Pond Closure	each	1	1	1	1	1	1	1	1	1	1
41	Pipeline Drain Pond Post Closure	each	1	1	1	1	1	1	1	1	1	1
42												
43	Well Abandonment											
44	Wellfield	each	38	58	78	95	116	132	150	150	148	152
45	HC wells	each	3	5	5	6	9	11	19	19	19	19
46	Observation wells	each	2	4	4	6	6	8	14	14	14	14
47	POC wells	each	3	3	3	3	3	3	3	3	3	3
48	IMW	each	31	29	27	26	26	26	26	25	25	23
49	Rinse Verification wells	each	0	0	0	0	0	0	0	4	6	8
50												
51	Post Closure Monitoring (3 POCs, 8 RVWs, 5 years)	Sample rounds	5	5	5	5	5	5	5	5	5	5
52												
53	Final Report	lump sum	0	0	0	0	0	0	0	0	0	0
54												

TABLE M-1
CLOSURE COST DETAIL

LINE	Closure Costs	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
55			Estimated Costs									
56	Prepare Work Plans	\$75,000	\$75,000	\$75,000	\$75,000	\$75,000	\$75,000	\$75,000	\$75,000	\$75,000	\$75,000	\$75,000
57	Mobilization	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000	\$20,000
58	Labor											
59	Project Manager	\$125	\$44,464	\$73,048	\$98,457	\$120,689	\$122,594	\$130,852	\$123,230	\$127,041	\$118,783	\$120,054
60	Wellfield Supervisor	\$72	\$102,446	\$168,304	\$226,844	\$278,067	\$282,457	\$301,483	\$283,921	\$292,702	\$273,676	\$276,603
61	Wellfield Operators (2)	\$56	\$159,360	\$261,806	\$352,869	\$432,549	\$439,378	\$468,974	\$441,655	\$455,314	\$425,719	\$430,272
62	Wellfield Electrician	\$44	\$62,606	\$102,852	\$138,627	\$169,930	\$172,613	\$184,240	\$173,507	\$178,873	\$167,247	\$169,035
63	Site Security	\$30	\$64,029	\$105,190	\$141,778	\$173,792	\$176,536	\$188,427	\$177,451	\$182,939	\$171,048	\$172,877
64	Overhead, Vehicles, & Expenses	10%	\$43,290	\$71,120	\$95,857	\$117,503	\$119,358	\$127,398	\$119,976	\$123,687	\$115,647	\$116,884
65	Labor for pullback pumping	\$	\$1,235,039	\$1,001,358	\$793,641	\$611,889	\$596,310	\$528,802	\$591,117	\$559,959	\$627,467	\$617,082
66												
67	Changing Pumps											
68	Capital Cost for pump replacements	\$2,990	\$71,760	\$104,650	\$140,530	\$170,430	\$167,440	\$158,470	\$158,470	\$152,490	\$152,490	\$161,460
69	Mobilization	\$1,500	\$1,500	\$3,000	\$3,000	\$3,000	\$3,000	\$3,000	\$3,000	\$3,000	\$3,000	\$3,000
70	Service Rig and Crew (2)	\$180	\$17,280	\$25,200	\$33,840	\$41,040	\$40,320	\$38,160	\$38,160	\$36,720	\$36,720	\$38,880
71	Per diem	\$350	\$4,200	\$6,125	\$8,225	\$9,975	\$9,800	\$9,275	\$9,275	\$8,925	\$8,925	\$9,450
72												
73												
74	Quarterly Reporting	\$1,620	\$4,860	\$8,100	\$11,340	\$12,960	\$12,960	\$14,580	\$12,960	\$12,960	\$12,960	\$12,960
75												
76	Rinsing, Pullback, Capital & Power Costs											
77	Mechanical Evaporator Capital (9 units)	91,000	\$819,000	\$819,000	\$819,000	\$819,000	\$819,000	\$819,000	\$819,000	\$819,000	\$819,000	\$819,000
78	Water Supply Power	\$268	\$35,002	\$57,504	\$77,505	\$95,006	\$96,506	\$103,007	\$97,006	\$100,006	\$93,506	\$94,506
79	Rinse Recovery Pumping Power	\$298	\$38,891	\$63,893	\$86,117	\$105,562	\$107,229	\$114,452	\$107,785	\$111,118	\$103,896	\$105,007
82	Pullback Pumping Power	\$72	\$36,723	\$32,105	\$27,486	\$22,867	\$18,249	\$18,249	\$18,249	\$18,249	\$18,249	\$18,249
83	Evaporation Power	\$1,127	\$146,922	\$241,371	\$325,326	\$398,787	\$405,084	\$432,369	\$407,183	\$419,776	\$392,491	\$396,688
84	Hydraulic Control Pumping Power (4 yrs)	\$298	\$14,894	\$16,579	\$18,264	\$19,950	\$21,635	\$21,635	\$21,635	\$21,635	\$21,635	\$21,635
85	Evaporation Power Pullback	\$1,127	\$578,045	\$505,345	\$432,645	\$359,946	\$287,246	\$287,246	\$287,246	\$287,246	\$287,246	\$287,246
86												
87	Rinsing Verification Sampling	\$1,350	\$32,400	\$5,400	\$6,750	\$8,100	\$8,100	\$8,100	\$8,100	\$8,100	\$8,100	\$8,100
88												
89	Maintenance: Evaporators, Pumps, Rigs		\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000
90												
91	Pond Closure											
92	Evaporation Pond Closure	each	\$749,925	\$749,925	\$749,925	\$749,925	\$749,925	\$749,925	\$749,925	\$749,925	\$749,925	\$749,925
93	Evaporation Pond Post Closure	each	\$23,625	\$23,625	\$23,625	\$23,625	\$23,625	\$23,625	\$23,625	\$23,625	\$23,625	\$23,625
94	Pipeline Drain Pond Closure	each	\$36,383	\$36,383	\$36,383	\$36,383	\$36,383	\$36,383	\$36,383	\$36,383	\$36,383	\$36,383
95	Pipeline Drain Pond Post Closure	each	\$11,375	\$11,375	\$11,375	\$11,375	\$11,375	\$11,375	\$11,375	\$11,375	\$11,375	\$11,375
96												
97	Well Abandonment											
98	Wellfield	\$16,448	\$648,660	\$970,660	\$1,249,760	\$1,562,600	\$1,899,920	\$2,156,240	\$2,445,200	\$2,442,200	\$2,410,160	\$2,468,240
99	HC wells	\$10,300	\$30,900	\$51,500	\$51,500	\$61,800	\$92,700	\$113,300	\$195,700	\$195,700	\$195,700	\$195,700
100	Observation wells	\$41,620	\$83,240	\$166,480	\$166,480	\$249,720	\$249,720	\$332,960	\$582,680	\$582,680	\$582,680	\$582,680
101	POC wells	\$46,987	\$140,960	\$140,960	\$140,960	\$140,960	\$140,960	\$140,960	\$140,960	\$140,960	\$140,960	\$140,960
102	IMW closure	\$10,600	\$328,600	\$307,400	\$286,200	\$275,600	\$275,600	\$275,600	\$275,600	\$265,000	\$265,000	\$243,800
103	RVW Closure	\$17,000	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$68,000	\$102,000	\$136,000
104												
105	Post Closure Monitoring (3 POCs, 8 RVWs, 5 years)	\$30,846	\$154,230	\$154,230	\$154,230	\$154,230	\$154,230	\$154,230	\$154,230	\$154,230	\$154,230	\$154,230
106												
108	Subtotal of Closure Liability by Year of Shutdown		\$5,865,609	\$6,429,487	\$6,853,538	\$7,382,258	\$7,685,253	\$8,097,315	\$8,659,602	\$8,734,819	\$8,674,842	\$8,766,906
109	Contingency for Unanticipated Costs	10%	\$586,561	\$642,949	\$685,354	\$738,226	\$768,525	\$809,731	\$865,960	\$873,482	\$867,484	\$876,691
110	Closure Liability by Year of Shutdown		\$6,452,169	\$7,072,436	\$7,538,892	\$8,120,484	\$8,453,778	\$8,907,046	\$9,525,563	\$9,608,300	\$9,542,326	\$9,643,596
111	Less Rinsing Credits		\$0	\$0	\$0	\$0	-\$132,489	-\$85,172	-\$164,034	-\$123,026	-\$135,644	-\$119,871
112	Net Closure Liability by Year of Shutdown		\$6,452,169	\$7,072,436	\$7,538,892	\$8,120,484	\$8,321,289	\$8,821,875	\$9,361,528	\$9,485,275	\$9,406,682	\$9,523,725

TABLE M-16
WELL ABANDONMENT COST DETAIL

			Y1		Y2		Y3		Y4		Y5		Y6		Y7		Y8		Y9		Y10	
NSH WELLS			30		30		30		30		30		30		30		30		30		30	
	Unit Cost		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity	
Mobilization and Demobilization (3)	\$ 10,000.00	lump sum	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -
ADWR Closure Notification	\$ 150.00	each	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500
Pump Removal (1)	\$ 1,200.00	each	30	\$ 36,000	30	\$ 36,000	30	\$ 36,000	30	\$ 36,000	30	\$ 36,000	30	\$ 36,000	30	\$ 36,000	30	\$ 36,000	30	\$ 36,000	30	\$ 36,000
Perforation of Well Casing (16)	\$ 25.00	ft	7500	\$ 187,500	7500	\$ 187,500	7500	\$ 187,500	7500	\$ 187,500	7500	\$ 187,500	7500	\$ 187,500	7500	\$ 187,500	7500	\$ 187,500	7500	\$ 187,500	7500	\$ 187,500
Abandonment of Open Boring with Type V Cement (10) (17)	\$ 12.00	ft	6500	\$ 78,000	6500	\$ 78,000	6500	\$ 78,000	6500	\$ 78,000	6500	\$ 78,000	6500	\$ 78,000	6500	\$ 78,000	6500	\$ 78,000	6500	\$ 78,000	6500	\$ 78,000
Abandonment of borehole with LCS screen and casing (18)	\$ 12.00	ft	7500	\$ 90,000	7500	\$ 90,000	7500	\$ 90,000	7500	\$ 90,000	7500	\$ 90,000	7500	\$ 90,000	7500	\$ 90,000	7500	\$ 90,000	7500	\$ 90,000	7500	\$ 90,000
Removal of casing 2 feet below grade (1)	\$ 150.00	each	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500	30	\$ 4,500
Disposal of Construction Debris	\$ 25,000.00	lump sum	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -
Oversight of well abandonments by Consultant (13)	\$ 75.00	hr	300	\$ 22,500	300	\$ 22,500	300	\$ 22,500	300	\$ 22,500	300	\$ 22,500	300	\$ 22,500	300	\$ 22,500	300	\$ 22,500	300	\$ 22,500	300	\$ 22,500
Project management by Consultant (14)	\$ 125.00	hr	30	\$ 3,750	30	\$ 3,750	30	\$ 3,750	30	\$ 3,750	30	\$ 3,750	30	\$ 3,750	30	\$ 3,750	30	\$ 3,750	30	\$ 3,750	30	\$ 3,750
Per Diem Consultant (15)	\$ 195.00	each	30	\$ 5,850	30	\$ 5,850	30	\$ 5,850	30	\$ 5,850	30	\$ 5,850	30	\$ 5,850	30	\$ 5,850	30	\$ 5,850	30	\$ 5,850	30	\$ 5,850
				\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600
average cost per well			\$ 14,420.00																			
Intermediate Monitoring wells(19)			31		29		27		26		26		26		26		25		25		23	
	Unit Cost		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity		Quantity	
Mobilization and Demobilization (3)	\$ 10,000.00	lump sum	0		0		0		0		0	\$ -	0		0		0		0		0	
ADWR Closure Notification	\$ 150.00	each	31	\$ 4,650	29	\$ 4,350	27	\$ 4,050	26	\$ 3,900	26	\$ 3,900	26	\$ 3,900	26	\$ 3,900	25	\$ 3,750	25	\$ 3,750	23	\$ 3,450
Pump Removal (1)	\$ 1,200.00	each	31	\$ 37,200	29	\$ 34,800	27	\$ 32,400	26	\$ 31,200	26	\$ 31,200	26	\$ 31,200	26	\$ 31,200	25	\$ 30,000	25	\$ 30,000	23	\$ 27,600
Perforation of Well Casing (2)	\$ 25.00	ft	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -	0	\$ -
Abandonment of Boring with Type V Cement (9)(11)	\$ 7.00	ft	35650	\$ 249,550	33350	\$ 233,450	31050	\$ 217,350	29900	\$ 209,300	29900	\$ 209,300	29900	\$ 209,300	29900	\$ 209,300	28750	\$ 201,250	28750	\$ 201,250	26450	\$ 185,150
Removal of casing 2 feet below grade (1)	\$ 150.00	each	31	\$ 4,650	29	\$ 4,350	27	\$ 4,050	26	\$ 3,900	26	\$ 3,900	26	\$ 3,900	26	\$ 3,900	25	\$ 3,750	25	\$ 3,750	23	\$ 3,450
Disposal of Construction Debris (1) (6)	\$ 25,000.00	lump sum		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -
Oversight of well abandonments by Consultant (13)	\$ 75.00	hr	310	\$ 23,250	290	\$ 21,750	270	\$ 20,250	260	\$ 19,500	260	\$ 19,500	260	\$ 19,500	260	\$ 19,500	250	\$ 18,750	250	\$ 18,750	230	\$ 17,250
Project management by Consultant (14)	\$ 125.00	hr	31	\$ 3,875	29	\$ 3,625	27	\$ 3,375	26	\$ 3,250	26	\$ 3,250	26	\$ 3,250	26	\$ 3,250	25	\$ 3,125	25	\$ 3,125	23	\$ 2,875
Per Diem Consultant (15)	\$ 195.00	each	31	\$ 6,045	29	\$ 5,655	27	\$ 5,265	26	\$ 5,070	26	\$ 5,070	26	\$ 5,070	26	\$ 5,070	25	\$ 4,875	25	\$ 4,875	23	\$ 4,485
				\$ 329,220		\$ 307,980		\$ 286,740		\$ 276,120		\$ 276,120		\$ 276,120		\$ 276,120		\$ 265,500		\$ 265,500		\$ 244,260
avg cost per well			\$ 10,620		\$ 10,620		\$ 10,620		\$ 10,620		\$ 10,620		\$ 10,620		\$ 10,620		\$ 10,620		\$ 10,620		\$ 10,620	
Rinse Verificaton wells Quantity (Recovery wells left open until end of LOM) (20)(21)			0		0		0		0		0		0		0		4		6		8	
Cost per well(20)				\$ 17,000		\$ 17,000		\$ 17,000		\$ 17,000		\$ 17,000		\$ 17,000		\$ 17,000		\$ 17,000		\$ 17,000		\$ 17,000
total liability for RVW abandonment				\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ 64,600.00		\$ 102,000.00		\$ 136,000.00
Abandonment Costs by year--Summary			Y1		Y2		Y3		Y4		Y5		Y6		Y7		Y8		Y9		Y10	
Wellfield			\$ 648,660		\$ 970,660		\$ 1,249,760		\$ 1,562,600		\$ 1,899,920		\$ 2,156,240		\$ 2,445,200		\$ 2,442,200		\$ 2,410,160		\$ 2,468,240	
HC wells			\$ 30,900		\$ 51,500		\$ 51,500		\$ 61,800		\$ 92,700		\$ 113,300		\$ 195,700		\$ 195,700		\$ 195,700		\$ 195,700	
Observation wells			\$ 83,240		\$ 166,480		\$ 166,480		\$ 249,720		\$ 250,020		\$ 332,960		\$ 582,680		\$ 582,680		\$ 582,680		\$ 582,680	
POC wells			\$ 140,960		\$ 140,960		\$ 140,960		\$ 140,960		\$ 140,960		\$ 140,960		\$ 140,960		\$ 140,960		\$ 140,960		\$ 140,960	
Existing NSH wells			\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600		\$ 432,600	
IMW Wells			\$ 329,220		\$ 307,980		\$ 286,740		\$ 276,120		\$ 276,120		\$ 276,120		\$ 276,120		\$ 265,500		\$ 265,500		\$ 244,260	
Rinse Verification Wells/Closure Verification Wells			\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ -		\$ 64,600		\$ 102,000		\$ 136,000	
TOTAL ABANDONMENT COST-all well types				\$ 1,232,980	\$ -	\$ 1,637,580	\$ -	\$ 1,895,440	\$ -	\$ 2,291,200	\$ -	\$ 2,659,720	\$ -	\$ 3,019,580	\$ -	\$ 3,640,660	\$ -	\$ 3,691,640	\$ -	\$ 3,697,000	\$ -	\$ 3,767,840

- NOTES:
- (1) from Yellow Jacket Drilling quote 7/29/16
- (2) Injection/recovery and Hydrualic control wells will be open hole construction. Casing will be grouted to minimum of 100 feet above bedrock surface. If a well is screened (with no annular materials), the screen will be removed prior to grouting. No perforation will be necessary for injection/recovery and hydraulic control wells.
- (3) Single mobilization/demobilization cost applies to all well types. The cost is Included in Injection/recovery well abandonment mob/demob
- (4) Most HC wells will be open hole construction, and casing will be grouted to minimum of 100 feet above bedrock surface. If a well is screened, the screen will be removed prior to grouting. There will be no annular materials in these wells. No perforation will be necessary.
- (5) It is assumed that annular materials have a porosity of 35% for grout volume calculations.
- (6) Single lump sum for all wells is included under the injection/recovery well costs.
- (7) Observation wells are piezometers and will not be equipped with pumps
- (8) POC and Observation wells will be installed with screen and annular materials. Perforations (2 per foot) are required under ADWR's standard abandonment method. Cost assumes average 1150 feet of perforation per well, which will bring peforations well above the historical water levels, as required by the
- (9) assumes average well depth of 1450 feet, average 1150 feet of grout
- (10) assumes 7-inch open borehole, per Yellow Jacket quote per foot cost of \$12
- (11) assumes 5-inch open borehole, pro-rated abandonment cost of \$7 per foot per conversation with Yellow Jacket.
- (12) assumes 4-inch diameter well in 9 inch diameter borehole, 35% annular materials porosity, pro-rated cost of \$10 per foot, per conversation with Yellow Jacket.
- (13) assumes 10 hours of oversight per well, using Clear Creek Technician I rate for this task.
- (14) assumes 1 hour of project management per well. Includes documentation and reporting of well abandonment.
- (15) assumes \$195 per well which includes perdiem (\$100) and truck rental (\$95)
- (16) Perforation only in low carbon steel casing (16 NSH wells), to a minimum of 20 feet above static water level. Total footage was compiled from as-built drawings for each well.
- (17) There are 12 NSH wells with open boreholes that will be abandoned.
- (18) There are 16 wells with LCS casing and screen. Assumes 4-inch diameter well in 10 inch diameter borehole, 35% annular materials porosity, pro-rated cost of \$12 per foot.
- (19) 31 IMWs are planned for years 1-15 of operation. IMWs will be plugged and abandoned when their location is in an active mining block. In year 1 there will be 31 IMWs. By year 10, eight IMWs will have been abandoned, leaving 23.
- (20) RVWs were previously used as recovery wells. Cost to abandon is same as recovery well. Approximately 10% wellfield injection recovery wells will have pumps removed and will be left open as rinse verification wells. The first RVWs will be in Year 8, representing 10% of the injection/recovery wells from year 1..
- (21) Closure verifaicaton wells are a subset of the RVWs. So no additional costs for closure of CVWs. They are included in the RVW closure costs.

CRAI Comment

54. *Following approval of the closure and post-closure costs, please submit a financial demonstration, including a financial assurance mechanism, that complies with the requirements of A.A.C. R18-9-A203(B). Until such time, this item remains as a requirement.*

EXCELSIOR RESPONSE:

Comment noted.

CRAI Comment

New Comment No. 55

55. ADEQ identified errors in the cost estimation spreadsheets pertaining to the closure and post-closure costs. ADEQ provided screenshots with comments to Mr. Paul Axelrod of Axelrod, Inc. and these comments were discussed on January 13, 2017 (see attachment). Based on the comment in the screenshots and discussions with Mr. Axelrod, please provide revised cost estimation spreadsheets.

Additionally, ADEQ identified the following errors pertaining to the revised Appendix M:

- a. In the text preceding Table M-4, there appears to be a typographical error in the cost per gallon which is presented as \$0.0003442/gallon or \$298.28/Mgal. Please acknowledge the error or provide a revised page.*
- b. Table M-11 has cost in linear feet for cutting and folding liner. Please explain how the cost to fold a liner is estimated based on liner feet vs. square footage.*

EXCELSIOR RESPONSE:

The closure and post-closure cost spreadsheet were revised in accordance with screenshot comments. Some of the comments are addressed in the attached technical memorandum and did not require revisions to the spreadsheet.

Errors pertaining to the revised Appendix M:

- a. There is a typographical error in the text preceding Table M-4. The cost should be \$298.28/Mgal.
- b. The reasons for basing the cost to fold a liner in Table M-11 on linear feet vs square footage are as follows:
 - i. At the time of closure, the evaporation pond will contain precipitate solids from process solutions. The liner will be cut at the anchor trench and on the slope and folded in by equipment such as a long reach excavator situated on the crest since the inside of the pond will not be accessible.
 - ii. The linear footage provided in the table for cutting and folding the liner is the pond perimeter at the crest where most of the work will be carried out.

OTHER COMMENT

ADEQ asked where unimpacted water from testing of injection/recovery wells will be stored.

EXCELSIOR RESPONSE:

Evaporation Pond #1 is designed to store the accumulated volume of precipitates generated from Stage 1 evaporation and interim lime addition during Stage 1 operations. At the start of the project, unimpacted water from well pumping tests will be stored in the pond for later use such as wellfield conditioning and dust control. The water will have been pumped out of the pond by the time evaporation activities are underway.

AXELROD, INC.

TECHNICAL MEMORANDUM

To: Ms. R. Sawyer, Excelsior Mining Corp	Info: Mr. R. Goodgame, Excelsior Mining Corp
From: P. Axelrod	Date: April 11, 2017
Project: Gunnison APP Application, Inventory No. 511633 – Request for Information	

This memo transmits responses to ADEQ's request for additional information on the Gunnison Copper Project closure costs. The information was requested in on screenshots of worksheets from the closure costs spreadsheet titled Stage 1 Closure Costs Gunnison Copper Project. The document was received on January 13, 2017 via email.

The screenshot comment is reproduced below in italics followed by the response.

Worksheet – Well closure Credits

What is the difference between a Cell (5-spots) and a Block?

There is no difference between a 5-spot and a Block. The spreadsheet annotation has been updated to refer to Blocks.

Early rinse 5 spots (blocks) total =55. There are 200 wells in Stage 1. What about the remaining wells?

The total 55 is the number of mining blocks that will be early rinsed (with three pore volumes). A total of 48 wells are scheduled to be closed by year 10 – see Worksheet **Well Sched 1-10**. The remaining wells will be rinsed after year 10 but the rinsing costs are included in the closure costs for year 10.

Late rinse blocks total = 38. What about the wells from year 9 (9 wells) and year 10 (8 wells)?

Late rinse blocks refer to the mining blocks that will be rinsed with two pore volumes. As for the above response, the remaining wells will be rinsed after year 10 and the rinsing costs are included in the closure costs for year 10.

Worksheet – HC Schedule-Cost

Observation Wells Added on the worksheet do not match the schedule in Table 18-1.

The worksheet will be updated to match Table 18-1.

Explain what Cumulative cost is.

Cumulative cost is the sum of costs from prior years. The worksheet table will be corrected since the cumulative costs are shown only for years 1 and 2. The costs for years 3 through 10 are annual costs. Closure costs are determined on an annual basis so the cumulative cost is not used for the calculations.

Worksheet – Rinsing Verification

There are supposed to be a total of 200 wells in Stage 1.

There are 200 wells in Stage 1. The top line of the worksheet represents 10 % of the wells added in each year. See the response to Comment 45, page M-9.

Worksheet – abandon v2

There is a discrepancy between the number of wells in year 5 scheduled for ADWR closure notification (8) and the number of wells scheduled for removal of casing (6).

Only 6 observation wells will exist in year 5 and the closure costs for year 5 allow for 6 wells to be abandoned.

Project management by consultant in year 5 should be 8 hours?

No, project management should be 6 hours, one hour for each well abandoned.

ADWR closure notification in year 7 – 14 wells, 6 wells added in year 7?

Yes, 6 wells will be added in year 7 giving a total of 14. The costs have been updated accordingly.

Worksheet – Closure Costs Rev 8-16-16

*Explain the calculation = $E2 * 830 * 3\% * 7.48052 / 1000000 * 5$*

The calculation is for 5 pore volumes for rinsing and consists of: the product of the mining block area E2, average depth of 830 feet, porosity of 3% converted to millions of gallons with factor $7.48/10^6$ and 5, the number of pore volumes. The calculation notation will be included on the worksheet.

Worksheet – Post Closure Mon

Is the mention of 16 samples an error?

Yes, it is an error, it should be 20 samples. The worksheet will be corrected.

The comment indicating the cost of \$42,410.75 is for sampling 3 POC wells for 4 quarters is confusing. Notes 1 is misleading too. I think it is primarily the cost for 5 annual sampling rounds. In think the Comment and the Note 1 appears to be typographical errors.

The cost of \$42,410.75 is for 5 annual sampling rounds. The comment and Note 1 are typographical errors and will be corrected.

Category	Rate	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10		
Early Rinse Blocks		block					14	9	8	7	9	8	▲ Paul Axelrod: These are early rinse blocks. Remaining wells will be rinsed after year of closure	
Pore volume @ 3% porosity per cell	1.863	Mgal					26.077	16.764	14.901	13.039	16.764	14.901		
Early Rinse volume	3 pore volumes	Mgal					78.231	50.292	44.704	39.116	50.292	44.704		
Water Supply Power Credits	\$268	\$/Mgal	Paul Axelrod: no difference between a cell (5-spot) and a block				\$21,001	\$13,501	\$12,001	\$10,501	\$13,501	\$12,001		
Rinse Recovery Pumping Power Credits	\$298	\$/Mgal					\$23,335	\$15,001	\$13,334	\$11,667	\$15,001	\$13,334		
Early Rinsate Pumping Credits	\$0	\$/Mgal					\$0	\$0	\$0	\$0	\$0	\$0		
Evaporation Power Credits	\$1,127	\$/Mgal					\$88,153	\$56,670	\$50,373	\$44,076	\$56,670	\$50,373		
Yearly Early Rinse Credits							\$132,489	\$85,172	\$75,708	\$66,245	\$85,172	\$75,708	▲ Paul Axelrod: These are late rinse blocks. Remaining wells will be rinsed after year of closure.	
Late Rinse Blocks		block							14	9	8	7		
Pore volume @ 3% porosity per cell	1.863	Mgal							26.077	16.764	14.901	13.039		
Late Rinse volume	2 pore volumes	Mgal							52.154	33.528	29.802	26.077		
Water Supply Power Credits	\$268	\$/Mgal							\$14,001	\$9,001	\$8,001	\$7,000		
Rinse Recovery Pumping Power Credits	\$298	\$/Mgal							\$15,557	\$10,001	\$8,889	\$7,778		
Late Rinsate Pumping Credits	\$0	\$/Mgal							\$0	\$0	\$0	\$0		
Evaporation Power Credits	\$1,127	\$/Mgal							\$58,769	\$37,780	\$33,582	\$29,384		
Yearly Late Rinse Credits							\$0	\$0	\$88,326	\$56,781	\$50,472	\$44,163		
Total Yearly Wellfield Rinsing Credits							\$132,489	\$85,172	\$164,034	\$123,026	\$135,644	\$119,871		

Table M-8 Verification Sampling Cost Estimate

				YEAR									
				Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Description	Qty	Rate	Unit	24	4	5	6	6	6	6	6	6	6
Sample collection (1 hours per sample--no purging required)	1.5	\$95.00	hr	\$ 3,420	\$ 570	\$ 713	\$ 855	\$ 855	\$ 855	\$ 855	\$ 855	\$ 855	\$ 855
Field Parameters Meter (Clear Creek Rate)	2	\$25.00	day	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50	\$ 50
Misc. field costs per well (2)	1	\$25.00	each	\$ 600	\$ 100	\$ 125	\$ 150	\$ 150	\$ 150	\$ 150	\$ 150	\$ 150	\$ 150
Mileage (from Tucson) based on 2 trips per year	280	\$0.55	each	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154	\$ 154
Field Truck (Clear Creek Rate)	2	\$95.00	daily	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190	\$ 190
Generator Rental (trailer mounted, from Sunstate Rentals)(3)	1	\$713.00	week	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713	\$ 713
Laboratory Costs (TURNER)(1)													
Dissolved Metals ICP (Sb, As, Ba, Be, Cd, Cr, Pb, Se, Th, Ni)	1	\$80.00	sample	\$ 1,920	\$ 320	\$ 400	\$ 480	\$ 480	\$ 480	\$ 480	\$ 480	\$ 480	\$ 480
Mercury dissolved	1	\$41.00	sample	\$ 984	\$ 164	\$ 205	\$ 246	\$ 246	\$ 246	\$ 246	\$ 246	\$ 246	\$ 246
Fluoride	1	\$20.00	sample	\$ 480	\$ 80	\$ 100	\$ 120	\$ 120	\$ 120	\$ 120	\$ 120	\$ 120	\$ 120
VOCs	1	\$150.00	sample	\$ 3,600	\$ 600	\$ 750	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900
TDS	1	\$21.00	sample	\$ 504	\$ 84	\$ 105	\$ 126	\$ 126	\$ 126	\$ 126	\$ 126	\$ 126	\$ 126
pH --field	1	\$0.00	sample	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
nitrate+nitrite	1	\$30.00	sample	\$ 720	\$ 120	\$ 150	\$ 180	\$ 180	\$ 180	\$ 180	\$ 180	\$ 180	\$ 180
dissolved U	1	\$150.00	sample	\$ 3,600	\$ 600	\$ 750	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900	\$ 900
Ra226 + Ra 228	1	\$195.00	sample	\$ 4,680	\$ 780	\$ 975	\$ 1,170	\$ 1,170	\$ 1,170	\$ 1,170	\$ 1,170	\$ 1,170	\$ 1,170
gross alpha	1	\$85.00	sample	\$ 2,040	\$ 340	\$ 425	\$ 510	\$ 510	\$ 510	\$ 510	\$ 510	\$ 510	\$ 510
Data Management, Reporting per sample	2	\$95.00	hr	\$ 4,560	\$ 760	\$ 950	\$ 1,140	\$ 1,140	\$ 1,140	\$ 1,140	\$ 1,140	\$ 1,140	\$ 1,140
Annual Cost				\$ 28,215	\$ 5,625	\$ 6,755	\$ 7,884	\$ 7,884	\$ 7,884	\$ 7,884	\$ 7,884	\$ 7,884	\$ 7,884
Unit Cost per Sample				\$ 1,176	\$ 1,406	\$ 1,351	\$ 1,314	\$ 1,314	\$ 1,314	\$ 1,314	\$ 1,314	\$ 1,314	\$ 1,314

Notes:

- (1) Unit Costs from Turner Laboratories in Tucson, AZ
- (2) Ice, disposables, fuel for generator.
- (3) weekly unit rate is marked up by 15%. Rate from SunState

Paul Axelrod:
There are 200 wells in Stage 1. The top line of the worksheet represents the % of wells added in each year. See the response to Comment 45, page M-9.

Alison Jones:
used this as the unit cost on Summary sheet

Worksheet - Closure Costs Rev 3-28-17

Closure Costs	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Mining Block Area	ft ²	140,000	00,000	00,000	70,000	00,000	00,000	80,000
Rinsing Volume (5 pore volumes)	Mgal	130.4						74.5
Cumulative Rinsing Volume	Mgal	130.4						361.4
Duration of Rinsing @ 400 gpm	days	249						690
Pullback Pumping Volume	Mgal	513	448	384	319	255	255	255

Paul Axelrod:

The calculation is for 5 pore volumes for rinsing: the product of the mining block area E2, average depth of 830 feet, porosity of 3% converted to millions of gallons with factor 7.48/106 and 5, the number of pore volumes.

	Quantity	Rate	Unit	markup %	Total	NOTE
Sample collection (8 hours per sample, 15 samples)	440	\$95.00	hr	0	\$41,800.00	(2)(3)
Field Parameters Meter	55	\$25.00	day		\$1,375.00	
Misc. field costs--5 events	5	\$300.00	lumpsum		\$1,500.00	(5)
Mileage (from Tucson) (15 days at 140 miles per day)	770	\$0.55	mile		\$423.50	(8)
Field Truck	55	\$95.00	daily		\$5,225.00	
Generator Rental (trailer mounted, from Sunstate Rentals)	10	\$713.00	week	15	\$8,199.50	(7)
Laboratory Costs						
Dissolved Metals ICP (Sb, As, Ba, Be, Cd, Cr, Pb, Se, Th, Ni)	65	\$80.00	sample	15	\$5,980.00	(1) (4)
Mercury dissolved	65	\$41.00	sample	15	\$3,064.75	(1) (4)
Fluoride	65	\$20.00	sample	15	\$1,495.00	(1) (4)
VOCs	65	\$150.00	sample	15	\$11,212.50	(1) (4)
TDS	65	\$21.00	sample	15	\$1,569.75	(1) (4)
pH --field	65	\$0.00	sample	0	\$0.00	(1) (4)
nitrate+nitrite	65	\$30.00	sample	15	\$2,242.50	(1) (4)
dissolved U	65	\$150.00	sample	15	\$11,212.50	(1) (4)
Ra226 + Ra 228	65	\$195.00	sample	15	\$14,576.25	(1) (4)
gross alpha	65	\$85.00	sample	15	\$6,353.75	(1) (4)
Data Management, Reporting	400	\$95.00	hr		\$38,000.00	
POC well plugging and abandonment						(6)
Oversight for well plugging and abandonment (5 POC wells)						(6)
Post-Closure Costs Total					\$154,230.00	

NOTES:

This is for 5 years post closure monitoring starting at end of Stage 1 (Year 10)

Assumptions

- (1) Total of 65 samples will be collected. ((3 POC wells+ 8 Closure Verification Wells) x (5 annual events) + (10 Duplicates))= 65 samples
- (2) 55 samples x 8 hours/sample = 440 hours
- (3) Duplicates not included in sampling time.
- (4) Unit Costs from Turner Laboratories in Tucson, AZ
- (5) Ice, disposables, fuel for generator.
- (6) Included in well abandonment spreadsheet
- (7) weekly unit rate is marked up by 15%. Rate from SunState

Yearly average

\$30,846.00

Alison Jones:
Price for sampling 3 POC wells for 5 years after wellfield rinsing.